NORTHERN GREAT PLAINS I&M NETWORK

Vital Signs Monitoring Plan

NATIONAL PARK SERVICE
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Draft

SIGNATURE PAGE

Superintendent Agate Fossil Beds National Monument	Date	Superintendent Missouri National Recreational River	Date
Superintendent Badlands National Park	Date	Superintendent Mount Rushmore National Memorial	Date
Superintendent Devils Tower National Monument	Date	Superintendent Niobrara National Scenic River	Date
Superintendent Fort Laramie National Historic Site	Date	Superintendent Scotts Bluff National Monument	Date
Superintendent Fort Union Trading Post National Historic Site	Date	Superintendent Theodore Roosevelt National Park	Date
Superintendent Jewel Cave National Monument	Date	Superintendent Wind Cave National Park	Date
Superintendent Knife River Indian Villages National Historic Site	Date	Inventory & Monitoring Coordinator Northern Great Plains Network	Date

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CHAPTER 1. INTRODUCTION AND BACKGROUND

The National Park Service (NPS) Organic Act directs the agency to "conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations" (16 U.S.C. 1 § 1). In spite of this clear mandate to conserve natural resources, many park units lack the natural resource information necessary to make sound and defensible management decisions. Due to this shortcoming, the National Parks Omnibus Management Act of 1998 stated that the NPS "shall undertake a program of inventory and monitoring of National Park System resources to establish baseline information and to provide information on long-term trends in the condition of the National Park System resources." This directive to implement a program of inventory and monitoring is echoed in the agency's own policies which state that the agency shall "define, assemble, and synthesize comprehensive baseline inventory data describing natural resources" and "use qualitative and quantitative techniques to monitor key aspects of resources and processes at regular intervals" (National Park Service 2000*b*:31). The intent of such inventory and monitoring programs is to detect or predict changes in natural systems and processes, take remedial action where necessary and feasible, provide reference points for comparison with other environments, and to monitor the integrity of the natural systems in the parks.

The 13 parks in the Northern Great Plains Network (NGPN: Network) have completed, or are in the process of completing, baseline inventories of natural resources, specifically the 12 basic datasets outlined in the NPS National Inventory & Monitoring (I&M) Program (http://science.nature.nps.gov/im/index.htm). The Network was primarily responsible for completing the baseline inventories for vascular plants and vertebrates, as outlined in the Network Inventory Study Plan (National Park Service 2002). Although the baseline inventories are generally completed, the Network will continue to develop and refine baseline natural resource information for the parks.

This document describes the next phase in the Network's I&M Program, that of monitoring the natural resources in the Network. This plan adheres to NPS guidance for monitoring programs, including guidance provided by the National I&M Program (Peterson et al. 1995, National Park Service 2000*b*, 2003). This plan is a collaborative effort among the 13 parks in the Network, developed in coordination and consultation with subject-matter experts, other agencies and organizations, and other expertise within the NPS.

NATIONAL PARK SERVICE MONITORING

National Park Service managers are confronted with increasingly complex and contentious issues that require a broad understanding of the status and trends of park resources. Knowing the condition of natural resources in park units—and the human impacts on those resources—is critical to meeting the NPS mission to manage resources in a manner that leaves them "unimpaired for the enjoyment of future generations" (16 U.S.C. 1 § 1). Achieving this mission generally requires a collaborative ecosystem approach towards monitoring and management because parks are open systems with external threats such as invasive species and air and water pollution. Furthermore, no single spatial or temporal scale addresses all system components and processes; i.e., the appropriate scale for understanding and effectively managing a resource might be at the genetic, individual, population, community, or landscape level. Consequently, management of resources may require local, regional, national, or international collaborative efforts.

The general approach of the NPS monitoring program is to track a subset of physical, chemical, and/or biological elements and processes affecting park ecosystems. These elements and processes are known within the NPS as *Vital Signs* (http://science.nature.nps.gov/im/monitor/glossary.htm). Vital Signs are the most effective and efficient indicators of ecological condition within park ecosystems and/or are those of greatest concern to park management. In situations where natural areas have been so altered that physical, chemical, and biological processes no longer operate naturally, information obtained through monitoring Vital Signs can help managers identify and implement remedial actions. Vital signs may occur at any level of organization including landscape, community, population, or genetic level, and may be compositional (referring to the variety of elements in the system), structural (referring to the organization or pattern of the system), or functional (referring to ecological processes).

LEGISLATION, POLICY, AND GUIDANCE

In establishing Yellowstone National Park in 1872 Congress dedicated and set apart the lands "as a … pleasuring ground for the benefit and enjoyment of the people" (16 U.S.C. 1 § 21). By 1900 a total of five national parks had been established along with similar areas such as historic sites. Each unit was administered according to its individual enabling legislation, but all had been created with a common purpose of preserving the "precious" resources for public benefit. Sixteen years later the passage of the NPS Organic Act of 1916 (16 U.S.C. 1 § 1) established and defined the mission of the NPS, and through it, Congress implied the need to monitor natural resources and guarantee unimpaired park resources:

> *"The service thus established shall promote and regulate the use of the Federal areas known as national parks, monuments, and reservations hereinafter specified … by such means and measures as conform to the fundamental purpose of the said parks, monuments, and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."*

Congress reaffirmed the Organic Act with the General Authorities Act of 1970 (16 U.S.C. 1a-1a8). The latter act effectively ensured that all park units be united into the "National Park System" by a common purpose of preservation, regardless of title or designation. In 1978, the NPS protective function was further strengthened when Congress amended the Organic Act to state "the protection, management, and administration of these areas shall be conducted in light of the high public value and integrity of the National Park System and shall not be exercised in derogation of the values and purposes for which these various areas have been established." More recent and explicit requirements for a program of inventory and monitoring are found in the National Parks Omnibus Management Act of 1998 (P.L. 105-391). That act explicitly called for an inventory and monitoring program "to establish baseline information and to provide information on the long-term trends in the condition of National Park System resources." Subsequently, the NPS updated its management policies to state (NPS 2000*b*):

> *"Natural systems in the national park system, and the human influences upon them, will be monitored to detect change. The Service will use the results of monitoring and research to understand the detected change and to develop appropriate management actions."*

The NPS management policies also clearly direct parks to conserve species native to the park, the natural structure and condition of those species, and the natural processes that affect and maintain them. The implication being that a park that supported and conserved a full assemblage of native species (and conversely, not non-native species) was a healthy park compared to one that did not do so, and that monitoring could detect these conditions. In addition to legislation specific to the NPS, there is other legislation which protects natural resources within NPS units. Some of these federal laws also require or recommend natural resource monitoring within park units. A summary of the legislation, policy, and executive guidance that has an important and direct bearing on the development and implementation of natural resource monitoring in the NPS is presented in Appendix B.

The Government Performance and Results Act (GPRA) of 1993 directs agencies to establish measurable objectives and to report on the progress towards meeting those objectives. The NPS has established four overarching goals under which more specific regional, program, and unit specific goals are established. They are:

- Category I goals preserve and protect park resources.
- Category II goals provide for the public enjoyment and visitor experience of parks.
- Category III goals strengthen and preserve natural and cultural resources and enhance recreational opportunities managed by partners.
- Category IV goals ensure organizational effectiveness.

The Network I&M Program will have a significant role in meeting NPS GPRA goals. For example, one GPRA goal calls for inventories of park resources as an initial step in preserving those resources (GPRA Goal Ib1). This monitoring plan establishes the Vital Signs of the Network and a strategy for long-term monitoring (GPRA Goal Ib3). In addition to the national GPRA goals, each park has a five-year plan that includes park-specific GPRA goals, some of which are relevant to the I&M Program.

INVENTORY & MONITORING GOALS

The goals established by the NPS National I&M Program for Vital Signs monitoring are:

- Determine the status and trends in selected indicators of the condition of park ecosystems to allow managers to make better-informed decisions and to work more effectively with other agencies and individuals for the benefit of park resources.
- Provide early warning of abnormal conditions of selected resources to help develop effective mitigation measures and reduce costs of management.
- Provide data to better understand the dynamic nature and condition of park ecosystems and to provide reference points for comparisons with other, altered environments.
- Provide data to meet certain legal and Congressional mandates related to natural resource protection and visitor enjoyment.
- Provide a means of measuring progress towards performance goals.

The Network has adopted these goals without modification. This plan outlines the approach the Network will take to achieve these goals. This plan also summarizes the work completed to date, the agencies and personnel involved, the anticipated costs to conduct the necessary work, and other relevant issues.

OVERVIEW OF PARKS IN THE NORTHERN GREAT PLAINS NETWORK

The Northern Great Plains I&M Network is comprised of a diverse group of NPS units ranging from old to new, large to small, and lightly to highly visited (Table 1). Some units have large staffs whereas other units have small staffs. Some parks focus primarily on natural resources, others focus primarily on cultural resources, and some are evenly split between the two. Some units, such as Mount Rushmore NMEM, are internationally known, while others are barely known even within the states in which they are located. Some units are along highly used highways while others are in extremely remote locations. The Network includes four national monuments (NM), three national historic sites (NHS), four national parks (NP), a national recreation river (NRR), a national scenic riverway (NSR), and a national memorial (NMEM). (Definitions of park designations can be found at http://www.nps.gov/legacy/nomenclature.html.) The units are located in North and South Dakota, the northern and western portions of Nebraska, eastern Wyoming, and extreme eastern Montana (Figure 1: Fort Union Trading Post NHS is bisected by the North Dakota/Montana border). Several parks, such as Badlands NP, the Missouri NRR, and Theodore Roosevelt NP, are comprised of non-contiguous management units.

Most of the park units are typical in that the federal government owns all or most of the land within the park boundaries and those boundaries are clearly marked in the field. However, the Missouri NRR and Niobrara NSR are notable exceptions. The lands within those units are primarily owned by private, state, and non-governmental conservation organizations. Those parks work closely with the landowners within the parks and other entities to achieve park goals. Badlands NP is also noteworthy in that approximately half of the park lies within the Pine Ridge Indian Reservation. The park manages the land within the reservation in cooperation with the Oglala Sioux Tribe as a trust resource under a 1978 Memorandum of Agreement (MOA). Badlands, Theodore Roosevelt, and Wind Cave NPs, and Jewel Cave NM and Mount Rushmore NMEM have a large portion of their boundary abutting other federal lands, specifically national grasslands and national forests administered by the U.S. Forest Service.

The operating budget for several of the parks is supplemented by non-base or non-park funds. For example, approximately half of the parks in the Network are in the Recreational Fee Demonstration program. This program can supplement park budgets. Although Mount Rushmore is not in that program, it has a significant concessions program that generates additional funds for park management. Parks in the Network also benefit from the multi-park FIREPRO program stationed at Wind Cave NP and the Exotic Plant Management Team (EPMT) stationed at Theodore Roosevelt NP. The former program includes a sub-division known as the Fire Effects monitoring program. Agate Fossil Beds NM and Scotts Bluff NM benefit from being in the Prairie Cluster Long-term Ecological Monitoring Program (LTEM) stationed out of Republic, Missouri.

Table 1. Overview of Parks in the Northern Great Plains Network

Park	Year Estab-lished[1]	Primary Purpose	Acres[2,4]	Base Funding (FY03)[2]	FTEs (FY02)[3]	Number of Visitors (FY02)[2]
Agate Fossil Beds NM	1965	Cultural/Natural	3,055	$496,000	9	17,634
Badlands NP	1929	Natural	242,756	$3,052,000	68	906,868
Devils Tower NM	1906	Natural	1,347	$768,000	17	407,688
Fort Laramie NHS	1938	Cultural	833	$1,198,000	22	47,641
Fort Union Trading Post NHS	1966	Cultural	444	$631,000	13	21,171
Jewel Cave NM	1908	Natural	1,274	$871,000	19	131,481
Knife R. Indian Villages NHS	1974	Cultural	1,758	$657,000	9	31,932
Missouri NRR	1978	Natural	69,123	$539,000	n/a	n/a
Mount Rushmore NMEM	1925	Cultural	1,278	$2,529,000	56	2,159,189
Niobrara NSR	1991	Natural	29,056	$695,000	7	n/a
Scotts Bluff NM	1919	Cultural/Natural	3,003	$739,000	15	113,885
Theodore Roosevelt NP	1947	Natural	70,447	$2,187,000	41	471,210
Wind Cave NP	1903	Natural	28,295	$1,877,000	52	696,402
TOTAL			**452,669**	**$16,239,000**	**321**	**5,005,101**

[1] I.e., the year originally authorized, proclaimed, or established. Many units had subsequent expansions, modifications, or redesignations.
[2] From http://data2.itc.nps.gov/parksearch/atoz.cfm except for Missouri NRR and Niobrara NSR which came from S. Wilson (pers. comm.).
[3] From http://inside.nps.gov/parks/
[4] Acres are defined as acres within the park boundary, which may differ from the actual fee acres owned by the federal government.

The Network includes parks from both the Inter-mountain (Devils Tower NM and Fort Laramie NHS) and Midwest Regions (all other parks) of the NPS. The Missouri NRR and Niobrara NSR share a superintendent. Superintendents of Fort Union Trading Post NHS and Knife River Indian Villages NHS are supervised by the superintendent of Theodore Roosevelt NP. Supervision of the superintendent at Jewel Cave NM is by the superintendent at Wind Cave NP. The superintendent at Agate Fossil Beds NM is supervised by the superintendent at Scotts Bluff NM. Many administrative functions, such as contracting, personnel, and information technology are shared by the parks through a multi-park program known as NEKOTA.

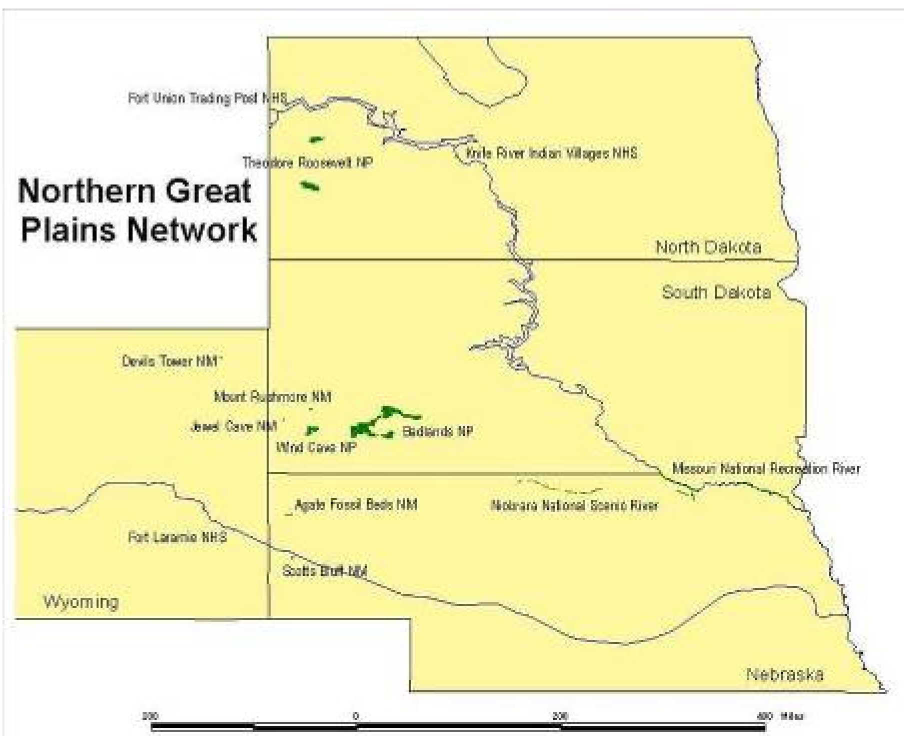

Figure 1. Location of Parks in the Northern Great Plains Network

Every park in the Network has significant natural resources; however, the status and size of natural resource programs in the parks varies considerably, with the larger parks typically having larger programs and staffs (Table 2). Larger staffs are generally correlated with the ability of the parks to procure additional funding for natural resource projects. Natural resource management in the smaller parks is often a collateral duty of law enforcement rangers or a superintendent. Table 2 lists the title of the park representative on the Network I&M Technical Committee. That person is typically the primary park contact for natural resources.

Table 2. Natural Resource Programs in Parks in the Northern Great Plains Network

Park	Job Title of the I&M Technical Committee Representative	Fulltime Permanent Natural Resource Positions
Agate Fossil Beds NM	Superintendent	None
Badlands NP	Chief of Natural Resources	Chief, Wildlife Biologist (2), Paleontologist, Generalist, Technician (2)
Devils Tower NM	Chief of Natural Resources	Chief
Fort Laramie NHS	Park Ranger (Natural Resource/Protection)	None
Fort Union Trading Post NHS	Superintendent	None
Jewel Cave NM	Physical Science Technician	Cave Specialist, Technician
Knife River Indian Villages NHS	LE Ranger	None
Missouri NRR	Supervisory Natural Resource Specialist	Generalist, Biologist/GIS, Hydrologist (½ FTE)
Mount Rushmore NMEM	LE Ranger	None
Niobrara NSR	Natural Resource Specialist	Generalist Hydrologist (½ FTE)
Scotts Bluff NM	Natural Resource Specialist	Generalist
Theodore Roosevelt NP	Chief of Natural Resources	Chief, Wildlife Biologist, Botanist, GIS Specialist
Wind Cave NP	Natural Resource Specialist	Chief, Natural Resource Specialist, Physical Science Specialist, GIS Specialist, Technician (3)

Larger parks tend to have more natural resource plans (Table 3). A few parks are initiating new plans under the new NPS planning guidance (Directors Order 2). Some park plans have or will included desired future conditions (DFCs); however, most parks do not have currently DFCs. The Northern Great Plains EPMT recently completed a plan for controlling exotic plants in the Network parks (with the exception of Badlands NP which developed a separate plan) and the Northern Great Plains FIREPRO program is working on fire plans for all parks.

Table 3. Status of Natural Resource Plans in Parks in the Northern Great Plains Network

Park	GMP	RMP	Fire Plan	Other
Agate Fossil Beds NM	Planned in FY04	2000	In prep	Wildfire Plan 1988
Badlands NP	In prep	1999	2004	Bighorn sheep in prep Bison in prep Black-footed ferret 1994 Weed Management 2003 Wilderness in prep
Devils Tower NM	2002	1998	2004	Climbing Management 1995 Exotic Plant in prep
Fort Laramie NHS	1993	Mid-90s	2004	Integrated Pest 2004 Vegetation in 2002
Fort Union Trading Post NHS	Yes	In prep	Yes	
Jewel Cave NM	1994	1999	In prep	Cave in prep Exotic Plant in prep Vegetation in prep
Knife River Indian Villages NHS	1986	1999	In prep	Prairie Management 1996

Missouri NRR	1997[1] 1999[1]	Planned for FY06		Exotic Plant Numerous plans by other agencies
Mount Rushmore NMEM	1987	91-92	2003	Climbing Management 1998
Niobrara NSR	In prep	In prep	In prep	Exotic Plant
Scotts Bluff NM	1998	1996	2001	Integrated Pest 1984
Theodore Roosevelt NP	1987	1994	1999	Elk in prep Water Resources 1998
Wind Cave NP	1994	In prep	In prep	Bison in prep Black-footed ferret in prep Black-tailed prairie dog in prep Cave in prep Elk in prep Vegetation in prep

[1] GMP for 39-mile District completed in 1997. GMP for 59-mile District completed in 1999.

OVERVIEW OF NATURAL RESOURCES IN THE NORTHERN GREAT PLAINS NETWORK

The Northern Great Plains I&M Network is located in a region that is sparsely populated with a strong agrarian culture. The human population in the region has been declining for decades, especially in rural areas dependent on agriculture (Popper and Popper 1987, Licht 1997*a*). This decades-long trend of economic and demographic stagnation and decline has led some to propose or predict a return to large areas of land dedicated to wildlife conservation (Popper and Popper 1994, Bock and Bock 1995, Callenbach 1996, Licht 1997*a*, Forrest et al. 2004); however, such a scenario seems far into the future if it happens at all. Although declining in economic significance, agriculture is still an important industry with ranching predominating in the western portion of the region and farming predominating in the eastern portion. Ranch and farm consolidation continues due to economic, demographic, and technological factors. Mineral and energy development are important locally, especially in western North Dakota and eastern Wyoming, although the industries often experience boom and bust periods. Coal mining and coal-fired power plants are especially common in western North Dakota and portions of Montana and Wyoming. Energy is also produced and dispersed from hydro-electric dams, primarily those on the Missouri River. Tourism continues to be a significant and growing factor in the region's economy, especially in the Black Hills area and for many of the smaller communities near national park units. Urban centers are comparatively small and widely spaced within the region. Some park units are significant distances from the nearest towns with year-round services. Scotts Bluff NM is the only park unit abutting an urban area. However, light residential and hobby farm development near park boundaries is a concern for some park units as people from elsewhere in the region look to retire near park units in part because of the amenities they provide. These historic, current, and future industries, land uses, and demographics constitute some of the stressors and opportunites for park resources. The socio-economic and cultural setting for the NGPN is shared only with the Southern Great Plains Network among NPS I&M networks. Comprehensive discussions of Northern Great Plains land use, economics, demographics, and culture can be found in Webb (1931), Popper and Popper (1987), Matthews (1992), Joern and Keeler (1995), Johnson and Bouzaher (1995), Manning (1995), Callenbach (1996), Licht (1997), and Wishart (2004).

All of the parks in the Network are located in the grassland or Great Plains biome, considered by some the largest biome in North America (Stubbendieck 1988). However, at a finer scale the 13 parks in the Network can be placed in three to five vegetative zones or biomes (Kuchler 1986, Omernik 1987, Bailey 1995). Bailey's (1995) classification placed seven parks in the shortgrass biome, four in the Black Hills ponderosa pine biome, one in the mixed-grass biome, and one split between mixed-grass and tallgrass biomes (Figure 2). However, the biome classification should be viewed cautiously since most of the parks in the Network support ecological communities characteristic of other biomes and/or ecosystems. For example, the Niobrara River Valley within the Niobrara NSR is widely recognized and lauded as having terrestrial communities representative of six ecological biomes including northern boreal, eastern deciduous, and western coniferous forests, and mixed-grass, tallgrass, and Sandhills prairies. Topography, rivers, groundwater, fire, biotic interactions, and historic uses all affect vegetation communities in the parks. Based on the USGS-NPS vegetation mapping effort (U.S. Geological Survey 2005) and other data, approximately 40% of the land area of the 13 parks is classified as native prairie, making it the largest cover type in the Network, followed by barren areas at 28% (primarily at Badlands NP) and forested areas at 10% (Table 3).

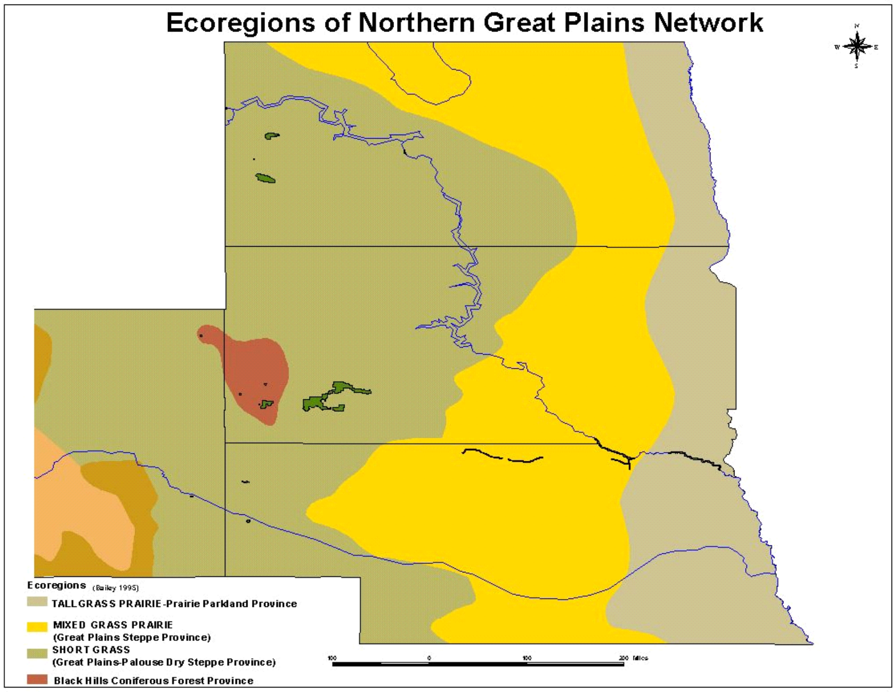

Figure 2. Ecoregions of the Northern Great Plains

The dominant native plant species in the region are grasses including Western wheatgrass, green needlegrass, and needle-and-thread in the cooler northern regions, blue grama and buffalograss in the more arid western regions, and big and little bluestem in the warmer and moister eastern regions. Ponderosa pine is predominant in the Black Hills and cottonwood is predominant along the larger streams and rivers. Species diversity is comparatively high in the prairie and riparian areas with hundreds of plant species typically found per square mile, whereas diversity is relatively poor within homogenous stands of ponderosa pine. Endemic plant species are rare compared to many other biomes, although they do exist. The Sandhills of central Nebraska are especially noteworthy in this regard in that they comprise one of the most distinct and heterogenous regions in North America with several endemic species. For a thorough discussion of vegetation resources in and near Network parks see Symstad (2004).

Fire, grazing, and weather (especially in regards to precipitation) are significant natural drivers of vegetation resources in the region. The absence or alteration of the first two drivers is a significant immediate concern. Fire and grazing have a profound influence on the composition, structure, and processes of Great Plains plant communities. Indeed, the absence of fire can change a grassland to a forest. Grazing, although still a dominant ecological process in the region, is applied in an unnatural uniform pattern across the landscape. Such pattern does not produce the landscape heterogeneity produced by historic grazing patterns (Hart and Hart 1997). Both grazing and fire have been absent or reduced in many of the park units in the Network, in some cases for decades. Perhaps more importantly, these drivers cannot operate at the landscape scale within park units because of the small size of the parks. Therefore, restoring plant community heterogeneity representative of the pre-European settlement Great Plains can only be done on a reduced scale. Weather, another natural ecological driver in the region, may change due to anthropogenically caused climate change, if it hasn't already. Changes to weather patterns, especially outside the normal range of variability, can have significant impact on grassland vegetation (Clark et al. 2002). In Weaver's (1943) classic vegetation study during and after the Dust Bowl of the 1930s he found that the mixed-grass prairie biome had moved a hundred miles to the east. In addition to Weaver's numerous studies (see also Weaver 1954), other notable documents on Great Plains plant ecology include Joern and Keeler (1995) and Knapp et al. (1998). Important taxonomy guides include the definitive Flora of the Great Plains (Great Plains Flora Association 1986), Grassland Plants of South Dakota and the Northern Great Plains (Johnson and Larson 1999), Plants of the Black Hills and Bear Lodge Mountains (Larson and Johnson 1999), and Vascular Plants of Wyoming (Dorn 2001).

Table 4. Land Cover of Parks in the Northern Great Plains Network

Park[1]	Forest	Shrubland	Native Prairie	Marsh/ Moist Soil	Barren	Surface Water	Human Disturbed Sites	Administrative Areas
Agate Fossil Beds NM	20 (1%)	24 (1%)	2,320 (75%)	234 (8%)	0 (0%)	1 (0%)	334 (11%)	150 (5%)
Badlands NP	3,590 (1%)	6,916 (3%)	111,944 (46%)	592 (0%)	111,999 (46%)	180 (0%)	6,800 (3%)	549 (0%)
Devils Tower NM	777 (58%)	13 (1%)	411 (30%)	0 (0%)	60 (4%)	9 (1%)	70 (5%)	3 (0%)
Fort Laramie NHS	104 (12%)	11 (1%)	348 (41%)	3 (0%)	63 (7%)	22 (3%)	243 (28%)	63 (7%)
Fort Union Trading Post NHS	50 (11%)	28 (6%)	126 (28%)	0 (0%)	0 (0%)	5 (1%)	203 (46%)	29 (7%)
Jewel Cave NM	1,215 (95%)	46 (4%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	2 (0%)	11 (1%)
Knife R. Indian Villages NHS	377 (22%)	78 (5%)	337 (20%)	3 (0%)	12 (1%)	112 (7%)	757 (44%)	32 (2%)
Missouri NRR	8,647 (13%)	0 (0%)	4,786 (7%)	10,326 (15%)	12 (0%)	31,104 (45%)	13,807 (20%)	0 (0%)
Mount Rushmore NMEM	1,112 (86%)	0 (0%)	0 (0%)	2 (0%)	113 (9%)	0 (0%)	0 (0%)	67 (5%)
Niobrara NSR	7,521 (26%)	0 (0%)	11,776 (41%)	1,235 (4%)	4 (0%)	5,836 (20%)	2,493 (9%)	0 (0%)
Scotts Bluff NM	230 (7%)	257 (8%)	1,544 (48%)	7 (0%)	687 (21%)	8 (0%)	472 (15%)	0 (0%)
Theodore Roosevelt NP	14,679 (21%)	9,553 (14%)	27,812 (40%)	28 (0%)	14,421 (21%)	651 (1%)	2,274 (3%)	551 (1%)
Wind Cave NP	8,170 (29%)	2,142 (8%)	17,049 (60%)	25 (0%)	276 (1%)	4 (0%)	394 (1%)	171 (1%)
TOTAL	46,492 (10%)	19,068 (4%)	178,453 (40%)	12,455 (3%)	127,593 (28%)	37,932 (8%)	27,849 (6%)	1,626 (0%)

[1] Data for all parks from the USGS Vegetation Mapping Program, except for the Missouri NRR and Niobrara NSR which came from the National Land Cover Dataset (1992). Acreages may not sum to actual acres within park boundaries due to methods used. Acreages are not directly comparable between park units due to differences in photo-interpreters and other factors. Surface water acreages may differ from Table 6 due to different methodology.

The Northern Great Plains historically supported a wildlife community that was similar in structure, processes, and behavior to grassland wildlife assemblages throughout the world (Knopf and Samson 1997). For example, the wide open terrain prior to European settlement lent itself to gregariousness, nomadicism, and migration. Many species such as bison, prairie dogs, locusts (i.e., grasshoppers when swarming), and migrating waterfowl occurred in almost unfathomable numbers. Other species, such as the wolf, typically occurred in much larger concentrations (i.e., packs) in the grassland biome than did their counterparts living in other habitats. This gregariousness and these long distance movements undoubtedly played a major role in shaping the grassland ecosystem. For example, it is generally believed that large numbers of bison grazed an area and then moved on, creating a mosaic of seral stages across the landscape (Hart and Hart 1997). Similarly, the grasshopper species, *Melanopus spretus*, also known as the Rocky Mountain locust, occasionally irrupted and migrated in great swarms, significantly altering the ecosystem, but then had negligible impact in other years (the species may now be extinct: Lockwood 2004). However, these processes, conditions, and characteristics of the Great Plains have been mostly lost due to habitat and ownership fragmentation. NPS policies direct park managers to preserve these landscape processes and conditions to the best extent possible, a challenge within the small size of the park units.

Bison and prairie dogs are especially noteworthy wildlife because their herbivory was likely a primary driver within the grassland ecosystem. The two species are often viewed as mutualistic (e.g., bison grazing encourages colonization by prairie dogs and prairie dog foraging promotes vegetation high in nutritional value for bison). Prairie dogs are also widely recognized as a keystone species or ecological engineer because of their burrowing, nutrient and soil cycling, and biomass for predators. Similarly, the gray wolf is noteworthy because of its ecological effects in the region. The absence of wolves (and bison) has greatly reduced the amount of carrion, which can be detrimental to species such as the swift fox and raven. The absence of wolves has also allowed coyotes and other meso-predators to flourish to the detriment of black-footed ferrets, ground-nesting birds, and many other species. The loss of all three has had a ripple effect through the prairie ecosystem that is greater than the loss of the species per se. A partial list of other mammal species lost from the biome and/or from individual national park units includes black and grizzly bears, swift fox, mountain lion, lynx, river otter, fisher, wolverine, elk, and bighorn sheep. The Great Plains has lost a greater number of native carnivores and ungulates than any other biome in North America (Laliberte and Ripple 2004).

Although the historic Northern Great Plains ecosystem was noted for its faunal biomass, it was not necessarily rich in terms of species composition. Outside of local biological hotspots, e.g., wetlands, riparian areas, and woody draws, vertebrate richness is generally poor. Only a handful of bird species comprise most of the avian population in both the grassland and ponderosa pine habitats. Likewise, reptile and amphibian richness is poor compared to many other North American ecosystems. Fish communities generally consist of a handful of smaller species well adapted to ephemeral conditions, although notable exceptions occur in the Missouri River and larger tributaries. This habitat specialization and poor species richness make Great Plains wildlife especially vulnerable to habitat alteration. For example, Knopf and Samson (1996) found that as a group the avifauna of the Great Plains has shown a steeper population decline than any other bird community in North America.

Wildlife resources still present in the region are valued by local residents, especially game species. Many parks support deer and other charismatic wildlife (Table 5). However, some wildlife species valued by the public are exotic to North America (e.g., pheasants) while others are likely alien to portions of the region (e.g., white-tailed deer). Indeed, the region is notable for the large number of exotics that have colonized it due to landscape alteration (Knopf 1992, Licht 1997*a*). So many birds have moved into the region due to human practices that the Great Plains have been referred to as a hybridization zone as eastern and western forest birds come together in the region (Rising 1983, Knopf 1994). In contrast, some native species are heavily persecuted because of perceived and real competition with current land use practices (e.g., prairie dogs). Only a few federally-listed species occur in the region and even fewer occur in Network parks. Examples of the latter are the black-footed ferret at Badlands NP, and the interior populations of piping plovers and least terns at the Missouri NRR and Niobrara NSR. For further information on pre-settlement Northern Great Plains wildlife see the various journals of Lewis and Clark (e.g., Burroughs 1961), John James Audubon, (Audubon 1897), and others, as well as summary documents such as Bailey's survey of North Dakota (Bailey 1926). For current wildlife conservation issues see Joern and Keeler (1995), Knopf and Samson (1996), and Licht (1997). There are state-specific guides for birds (Sharpe et al. 2001, Tallman et al. 2002), mammals (Higgins et al. 2000), and butterflies (Marrone 2002, Royer 2003) for most or all states within the Network.

Table 5. Notable Resident Wildlife Resources in Network Parks

Park	Ungulates										Federally-Listed T&E Species					Plants	
	Bison	Elk	Horse	Bighorn Sheep	Mule Deer	White-tailed Deer	Pronghorn	Mountain Goat	Mountain Lion	Prairie Dog	Bald Eagle	Black-footed Ferret	Least Tern	Piping Plover	Pallid Sturgeon	Globally Vulnerable Plants	Globally Vulnerable Communities
Agate Fossil Beds NM						X										2	4
Badlands NP	867			90	270	110	120		X	6,284		<10				2	12
Devils Tower NM					X	X				40							9
Fort Laramie NHS			32[1]			X											3
Fort Union Trading Post NHS						X											2
Jewel Cave NM		X			X	X			X								4
Knife R. Indian Villages NHS						X											4
Missouri NRR						X					14		247	170	X	n/a	n/a
Mount Rushmore NMEM					X			X	X								5
Niobrara NSR						X							13	9		n/a	n/a
Scotts Bluff NM					X	X				90						1	6
Theodore Roosevelt NP	610	750	90	20	X	X	X		X	1,230						1	11
Wind Cave NP	400	825[2]			150	50	60		X	2,000							10

Population estimates are generally from spring/summer of 2004 for birds and late summer to winter of 2004-05 for large mammals (estimates from respective park staff to D. Licht). Large mammal numbers are number of individuals. Prairie dog numbers are acres occupied. Bird numbers are breeding pairs. X = species present on a regular basis but no estimate available. n/a = not available. Globally vulnerable plants and communities are those ranked G3 or worse (from Sysmstad 2004).

[1] 28 of the animals are pastured at the park for the winter only. Includes mules.

[2] Elk use is seasonal with 400-425 in summer and 800-850 in 2004-05.

Surface water has always been a scarce resource in the western portion of the Great Plains, although significant changes in the amount and permanency of surface water have occurred since pre-Columbian times as a result of ranching (e.g., stock ponds), irrigation, flood control, and other anthropogenic changes. Surface water is typically a minor component of Network parks as measured by surface area, with the exception being the Niobrara NSR and Missouri NRR where surface water is a primary feature of the landscape (Table 4 and Table 6). However, water plays a disproportionate role in all parks in terms of species richness and abundance, ecological function, and visitor use. All parks in the Network have permanent surface water with the exception of Jewel Cave NM where natural surface water consists of seasonal springs and ephemeral streams (there is also a sewage pond) and Fort Union Trading Post NHS where the park boundary stops at the high water mark of the Missouri River (Table 6). Altered river hydrographs from dams, irrigation and municipal withdrawals, groundwater depletion, and other land use changes are a significant impact to aquatic systems in the Great Plains (Longo and Yoskowitz 2002). In many cases these altered hydrographs have impacted riparian flora and fauna, streambed structure and function, and water quality. Water quality has also been affected by herbicides and other pollutants. Several parks have Clean Water Act 303(d) impaired waters (Table 6). However, some impacts to park water resources are counter to conventional views of water quality. For example, Missouri River water has less turbidity now than under natural conditions, making these "cleaner" waters less healthy from the perspective of biotic integrity and native species (e.g., the endangered pallid sturgeon thrives best in turbid waters where predators are less likely to find it). Similarly, water quality in the pre-Columbian Great Plains was undoubtedly affected by the 15-30 million bison and other large ungulates (Hart and Hart 1997). The Missouri NRR and Niobrara NSR include Outstanding Natural Resource Waters as defined by the Clean Water Act.

Subsurface water quantity and quality is an important resource and management issue in some Network parks due to groundwater depletion from neighboring lands (primarily for irrigation) and groundwater pollution from pesticides (primarily herbicides) and hydrocarbons. The latter is of high concern in Jewel Cave NM and Wind Cave NP due to the locations of parking lots and roads. Groundwater depletion is of regional concern for both Great Plains ecology and society. Luckey et al. (1988) reported groundwater declines of 50-100 ft in the vicinity of Network parks in western Nebraska. Kromm and White (1992) observed that groundwater depletion has destroyed much of the water-supported habitat for fish and mammals in parts of the Great Plains. They reported that more than 700 miles of once permanently flowing rivers in Kansas no longer flow year round. For a thorough review of Great Plains water resources and management issues see Longo and Yoskowitz (2002).

In terms of climate the Northern Great Plains is classified as continental with hot summers and cold winters. However, there is often great variability between days, seasons, and years. According to Wilken (1987) the dramatic weather extremes in the Great Plains are really part of the "normal" events for the region. Severely harsh winters with long periods of snow cover occur periodically and can cause significant mortality for some wildlife. Precipitation, which occurs in the form of rain and snow, is light to moderate and generally increases from west to east; however, the Great Plains regularly goes through multi-year droughts on a cycle that has ranged from 10-20 years over the past few centuries (however, pre-Columbian cycles may have lasted much longer; Clark et al. 2002). This inter-year variability and the environmental bottlenecks it causes can confound efforts to analyze and interpret temporal and spatial trends and to identify causative factors in changes in natural resources. Furthermore, precipitation can show large local variation, requiring site-specific weather monitoring for accurate results. Winds are generally from the west making the Network prone to air quality issues in Montana and Wyoming. The impact of global climate change may be exacerbated in the Northern Great Plains due to the region's periodic droughts and the large number of habitat specialists (Collins and Glenn 1995, Clark et al. 2002). See Wilken (1987) for an overview of Great Plains climate.

The Great Plains is renowned for its clean air, distant horizons, and "big sky." Those characteristics are generally still true today as air resources in the region are less impacted than many other parts of the country. For example, the risk of ozone impacts to vegetation in the region is low (Kohut 2004) although some ozone-senstive species, such as ponderosa pine, are common (Miller 1973). However, increases in ariborne pollutants such as nitrate, sulfate, and ammonium have been noted (Pohlman 2005). Furthermore, significant oil and gas development is being proposed or initiated in Wyoming, Montana, and western North Dakota. Such development, along with the prevailing westerly currents, could affect most of the parks in the Network. In addition, several parks in the Network, such as Theodore Roosevelt NP and Knife River Indian Villages NHS, both in North Dakota, have energy extraction or power plants within 10 miles of their boundaries. Badlands, Theodore Roosevelt, and Wind Cave NPs are all Class I air quality areas. For a thorough discussion of air resources in the Network see Pohlman (2005).

Table 6. Aquatic and Other Natural Resources in Network Parks

Park	Miles of Perennial Stream in Park	Miles of Perennial Stream Bordering Park	Miles of Inter-mittent Stream	Miles of Canal	Acres of Lakes or Reser-voirs	Wet-lands	303(d) Listed Waters	303(d) Impairments	ONRW	Caves	Wilder-ness Acres	Class I Air Quality Area
Agate Fossil Beds NM	8.46		4.01	0.77		X						
Badlands NP	3.77		715.80		115.29		White River	pathogens, solids			64,250	X
Devils Tower NM	0.86	1.33	1.14				Belle Fourche R.	pathogens				
Fort Laramie NHS	2.50	1.35	0.56	0.06		X						
Fort Union Trading Post NHS		1.18	0.05			X	Missouri R.	flow, thermal				
Jewel Cave NM			4.08							X		
Knife R. Indian Villages NHS	4.36	0.08	0.99			X	Knife River	pathogens				
Missouri NRR	139.31		12.52	2.71	329.50	X	Choteau C. Dry Choteau C.		Missouri R.			
Mount Rushmore NMEM	0.01					X	Laferty Gulch					
Niobrara NSR	91.65		9.89		21.63	X	Niobrara R. Minnechaduza C. Plum C. Long Pine C.	patho., thermal pathogens pathogens	Niobrara R.			
Scotts Bluff NM		1.50					North Platte R.	pesticides, PCBS, thermal				
Theodore Roosevelt NP	21.20	7.38	268.80		5.33		Little Missouri R.	pathogens			29,920	X
Wind Cave NP	7.51		63.50		1.23	X				X		X
Total	279.63	12.82	1,081.34	3.54	472.98						94,170	

Water data from USGS 1:100,000 scale National Hydrography Dataset. Known errors include the estimate for canals at Scotts Bluff NM and intermittent streams at Mt. Rushmore NMEM. Lakes and reservoirs in Badlands, Theodore Roosevelt, and Wind Cave NPs consist solely of small impoundments created for livestock or wildlife. ONRW is Outstanding Natural Resource Waters as defined by the Clean Water Act. North and South Dakota have not designated such waters.

Northern Great Plains geology is generally the result of glaciation, water, wind and geologic uplift. For example, the badlands topography in Badlands and Theodore Roosevelt NPs and Agate Fossil Beds and Scotts Bluff NMs is the result of layers of sediment being deposited from the Rocky Mountains and Black Hills millions of years ago and then that sediment subsequently being eroded by rivers that carved numerous deep channels into the earth. In contrast to that geologic history, the Niobrara NSR is located in the Nebraska Sandhills, a region that was once a vast sand dune, the result of fine wind-blown material from past periods of glaciation. The rugged granite core of the Black Hills is the result of a geologic uplift millions of years ago. Mt. Rushmore NEM is located in the heart of this geologic region. Encircling the granite core is a limestone formation filled with caves, including Wind Cave and Jewel Cave. Devils Tower is world renowned for the cylindrical tower that is the result of a lava extrusion and then subsequent erosion surrounding the tower. Geologic resources are very important in the Network, and a primary natural resource and visitor attraction in several park units. For example, Jewel Cave NM and Wind Cave NP were both established because of the caves, Devils Tower because of the tower, and Badlands and Theodore Roosevelt NPs because of their unique and inspiring badlands topography. Geology is also important to the riverine parks as they are constantly struggling with balancing the natural process of changing river geomorphology with the need to protect park cultural resources. Geologic resources are also important to several parks as they relate to paleontological or archeological resources, e.g., Agate Fossil Beds NM, Badlands NP, and Niobrara NSR.

Great Plains soils range from deep, loamy, and fertile in the eastern portion of the region to shallow and hard in the western portion. The soils are generally nitrogen and carbon poor, although there is wide variability. Soil nutrient transport is generally slow; however, fire and grazing (especially under historic patterns) can cause rapid pulses of transport. Low soil moisture is often a stressor for plants. A large portion of prairie life actually occurs in the soil layer. For example, roughly 85% of a prairie's vegetative biomass can be below ground (Sims and Singh 1971). Risser et al. (1981) estimated that a square yard of tallgrass prairie soil, to a depth of 20 inches, may contain over 110,000 arthropods and 5.4 million nematodes. Even many of the vertebrate species in the region are fossorial, including praire dogs, a keystone species in the system. The soils, especially in the western portion of the Great Plains and in the Nebraska Sandhills, are susceptible to erosion once the protective vegetative layer is removed. This was dramatically demonstrated in the Dust Bowl of the 1930s. Although the epicenter of that event was in the Southern Great Plains, it also had an impact on the Northern Great Plains. Most of the national grasslands that abut some of the Network parks were aquired by the government to stop the soil erosion (and to bail out failing farms), as were portions of some of the park units. Although the parks are generally in areas not well suited to cultivation, some parks do contain tracts of formerly cultivated land. Chronic heavy grazing by livestock can compact soils and affect many of their characterstics and functions (e.g., water infiltration). For a thorough review of Great Plains soil characteristics and ecology see Seastedt (1995) and Ransom et al. (1998).

In summary, the Northern Great Plains Network is located in a singular ecological and cultural environment. The agrarian-dominated landscape, the small size of the parks, and the scale at which ecological processes naturally occurred in the region, all affect park management. None of the parks are large enough to restore and maintain complete assemblages of native species, natural conditions on a pre-European scale, nor the ecological processes that sustained them. Monitoring and management of park resources must occur within that context. For detailed and extensive imformation on the region see Wishart (2004). For more information on the ecology and economics of the region see Licht (1997) and for information on conservation and natural resources see Joern and Keeler (1995), Johnson and Bouzaher (1995), and Forrest et al. (2004).

PARKS IN THE NORTHERN GREAT PLAINS NETWORK

Agate Fossil Beds National Monument

ENABLING LEGISLATION/HISTORICAL CONTEXT:
Agate Fossil Beds NM was authorized in 1965. The park was established primarily for the abundance of Miocene epoch mammal fossils. The first human use of the site may have been 2,500 years ago. There is evidence that 31 currently recognized tribes may have used the site at one time or another. In 1879, Dr. Elisha Graham selected the site for a ranch, and his son-in-law, James Cook, acquired it in 1887. The ranch was a gathering place for Chief Red Cloud and other Oglala Lakota Indian people, making the site of considerable cultural significance. The site was subsequently operated as a cattle ranch by the Skavdahl and Buckley families. A small portion of one river terrace was cultivated for one growing season in the 1950s and other small areas in the park were used as corrals. Prior to park establishment hundreds of trees were planted at the site, but only a few remain (National Park Service 1980).

PARK MISSION:
The park mission is to preserve and interpret internationally significant paleontological resources of the Miocene epoch as well as nationally significant remains of Native American life at the closing of the frontier. The park also preserves and interprets other significant natural and cultural resources.
GENERAL DESCRIPTION:
Located in the Niobrara River drainage in northwestern Nebraska, Agate Fossil Beds NM consists of 3,055 acres, of which 2,270 acres are federal fee land. The park lies in a very remote and sparsely populated region where ranching is the primary industry. Some irrigated cultivation occurs, primarily from withdrawals of the Niobrara River or from center-pivot systems. Agate is an internationally recognized fossil site. Two hills, known as Carnegie and University Hills, are the most famous paleontological sites although fossils can be found elsewhere in the park. The first scientific exploration for fossils occurred in 1892 and the site was later visited by the famous paleontologists Edward Cope and Othniel Marsh as well as many others. There are no significant excavations going on at this time. Park visitation is light and primarily occurs in the summer months. Many visitors hike the trail to the fossil sites, but otherwise do not stray far from established routes. There is no overnight camping, hunting, or trapping. A very limited amount of fishing takes place in the river.

DESCRIPTION OF NATURAL RESOURCES:
Land cover of Agate Fossil Beds NM is about 75% native prairie, 11% disturbed sites (e.g., formerly cultivated areas), and 8% moist soil or marsh, with lesser amounts of other types (Aerial Information Systems 1998*a*: see Table 4). The extensive native prairie, the Niobrara River and associated wetlands, and the abundance of fossils are viewed by park personnel as the most significant natural resources at the park. The scenic vistas and natural soundscape are also considered important. The park's ungrazed prairie provides diversity within a landscape grazed by cattle; however, the lack of grazing within the park per se may be detrimental to some flora and fauna.

The following information on plant resources comes from the 1996-97 NPS/USGS vegetation mapping effort (Aerial Information Systems, 1998*a*). The park includes 13 vegetation types, the most common being *Sand Bluestem / Prairie Sandreed Prairie* and *Needle-And-Thread / Blue Grama Mixed-Grass Prairie*. The only vegetation type in the park considered globally vulnerable is the *Baltic Rush Wet Meadow* which contains some unusual and disjunct species. The *Cottonwood / Peachleaf Willow Floodplain Woodland* type along the Niobrara River may also be globally vulnerable; however, there is no regeneration of cottonwoods within that type, suggesting a deteriorating condition. The trees that now exist in the park probably occurred directly or indirectly from humans. Although most of the previously cultivated areas in the park have been seeded with native plants and are in fair shape, the former corral areas remain somewhat disturbed and are characterized by weeds. Other than these sites the upland vegetation is in relatively good shape and mostly free of invasive plants. The riparian plant community is considerably more compromised by exotics, specifically Canada thistle and yellow flag iris. The potential status of the yellow flag iris as a cultural resource complicates management actions. For a more thorough discussion of plant resources at the park see Symstad (2004). The park supports many wildlife species native to the region, although the absence of bison is a significant exception. Graetz et al. (1995), Powell (2000), Schmidt et al. (2004), Lawson (2004), and studies by the Prairie Cluster LTEM program and others have contributed to the list fauna at the park. The relatively high bird richness at the park may be due in part to anthropogenic alteration of the landscape (e.g., planting of trees). Rattlesnakes are common and noteworthy because of their interactions with visitors and park staff. The park provides habitat for 10 fish species, including the Iowa darter and plains topminnow, both species of concern in Nebraska. Non-native brown and rainbow trout are also part of the fish community. Pronghorn are transient in the vicinity of the park and swift fox observations are occasionally reported.

The park does not support any resident federally-listed threatened or endangered species. Whooping cranes and bald eagles may pass through the park, but there are no recent records. Ten species on the Nebraska Plants of Concern list (http://www.natureserve.org/nhp/us/ne/plants.html) have been confirmed in the park. The lesser yellow lady's-slipper occurs at the park and is on the Forest Service Rocky Mountain Region sensitive species list. There are no state-listed animals known to reside at the park. The park has about 8.5 miles of perennial stream, 4.0 miles of intermittent stream, and 0.8 miles of canal (based on the USGS National Hydrography Dataset: see http://www1.nrintra.nps.gov/wrd/dui/). The Niobrara River is a significant resource and the sole source of natural surface water in the park. The main channel of the river is only about 5 feet wide; however, there are extensive wetlands and moist soil areas associated with the river. The sweeping views and unaltered horizons are a significant resource and characteristic of both the park and the region. Noise pollution is often non-existent except for the occasional traffic on the east-west road through the park.

NATURAL RESOURCE GOALS AND OBJECTIVES:
An undocumented natural resource goal of Agate Fossil Beds NM is to contribute to the conservation of biological diversity in northwest Nebraska.

NATURAL RESOURCE ISSUES:
Significant natural resource issues at the park include exotic plants, the absence of grazing and fire, altered river flows within the Niobrara, and degraded water quality. Natural resource monitoring and management at the park is limited by the small park budget and staff.

Exotic plants such as Canada thistle and yellow flag iris are important management issues for the park. The park has an active program to control Canada thistle; however, monitoring of the effectiveness of the control is inadequate. No prescribed fires have occurred at the park since its authorization (and probably while in private ownership as well). This may have a detrimental effect on fire-evolved upland vegetation (Symstad [2004] stated that there did not seem to be a uniformly dense litter layer). Likewise, the absence of grazing may be an issue to vegetation resources. A prescribed burn program may be implemented in the near future and the return of bison is being conidered. The park would like information on the effects of these activities on park vegetation and other resources. Alterations to the river hydrograph, along with the absence of fire and grazing, may have changed the riparian area from a grassland/forb community to a willow community. The park would like to reintroduce bison for ecological, cultural, and visitor experience purposes. Some park employees believe that white-tailed deer are replacing mule deer at the park, perhaps due to regional changes in the landscape. Chronic wasting disease (CWD) has been documented in the vicinity of the park; its potential impacts on deer are a concern to park management. Maintaining the Niobrara River fishery is important to the park; upstream withdrawals for irrigation threaten the river ecosystem and the fishery. Upstream pesticide use, fertilizers, and ranching may have some impacts on water quality. Other natural resource issues include the effect that visitors are having on geological resources and maintaining the viewscape and soundscape of the park.

PARK-SPECIFIC MANDATES AND REQUESTS TO MONITOR NATURAL RESOURCES:
The park is implicitly mandated by the enabling legislation to monitor fossils and geology at the park. There are no other specific directives or mandates in regards to monitoring natural resources. Local governments would like the park to monitor (and control) noxious weeds.

CURRENT MONITORING PROJECTS:
Agate Fossil Beds NM is part of the Prairie Cluster LTEM Program. As a result, the park has a comparatively rich natural resource monitoring program. The LTEM Program is currently conducting vegetation, bird, and water quality monitoring at the park (see Peterson et al. 1999, Thomas 2001). It is anticipated that these monitoring efforts will continue until the Network is ready to begin field operations, at which point they will be conducted by the Network I&M Program in their current form, a modification thereof, or the monitoring will be discontinued. In addition to the LTEM monitoring, the park conducts weather monitoring using a Remote Automated Weather Station (RAWS) that collects hourly data. Park personnel also collect daily weather data (e.g., temp, precipitation, snow depth) for NOAA using other weather equipment. A NOAA Climate Reference Network Station began operation in 2004. A Breeding Bird Survey route passes through the west end of the park. The park maintains a database of wildlife observations along with a separate log for observations of snakes. The park monitors the distribution of Canada thistle as part of the treatment effort. Park personnel monitor water wells twice a month for drinking water standards. A flow gauge (purchased by the NPS) is located on the Niobrara River near the Agate Springs Ranch; the gauge is monitored by the State of Nebraska. Irrigation withdrawals from the Niobrara River are monitored by the State of Nebraska just downstream from the park. A complete list of past and current monitoring and replicable research efforts in and near the park can be found in Appendix D.

ADDITIONAL INFORMATION:
Detailed information on the park can be found at http://www.nps.gov/agfo/index.htm and other NPS web sites, in a history of the park by Cockrell (1986), and in the official NPS handbook for the park (National Park Service 1980).

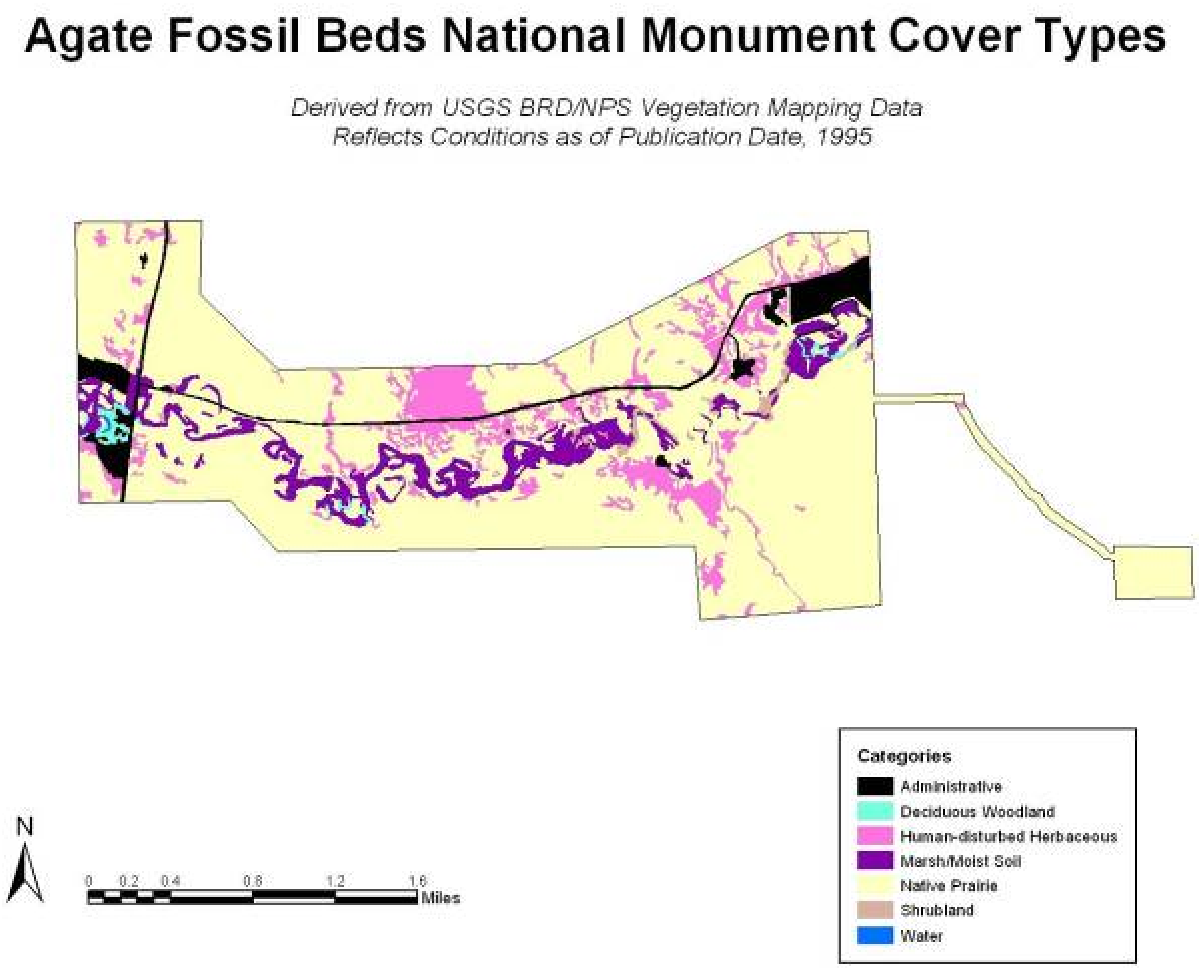

Figure 3. Agate Fossil Beds NM Land Cover

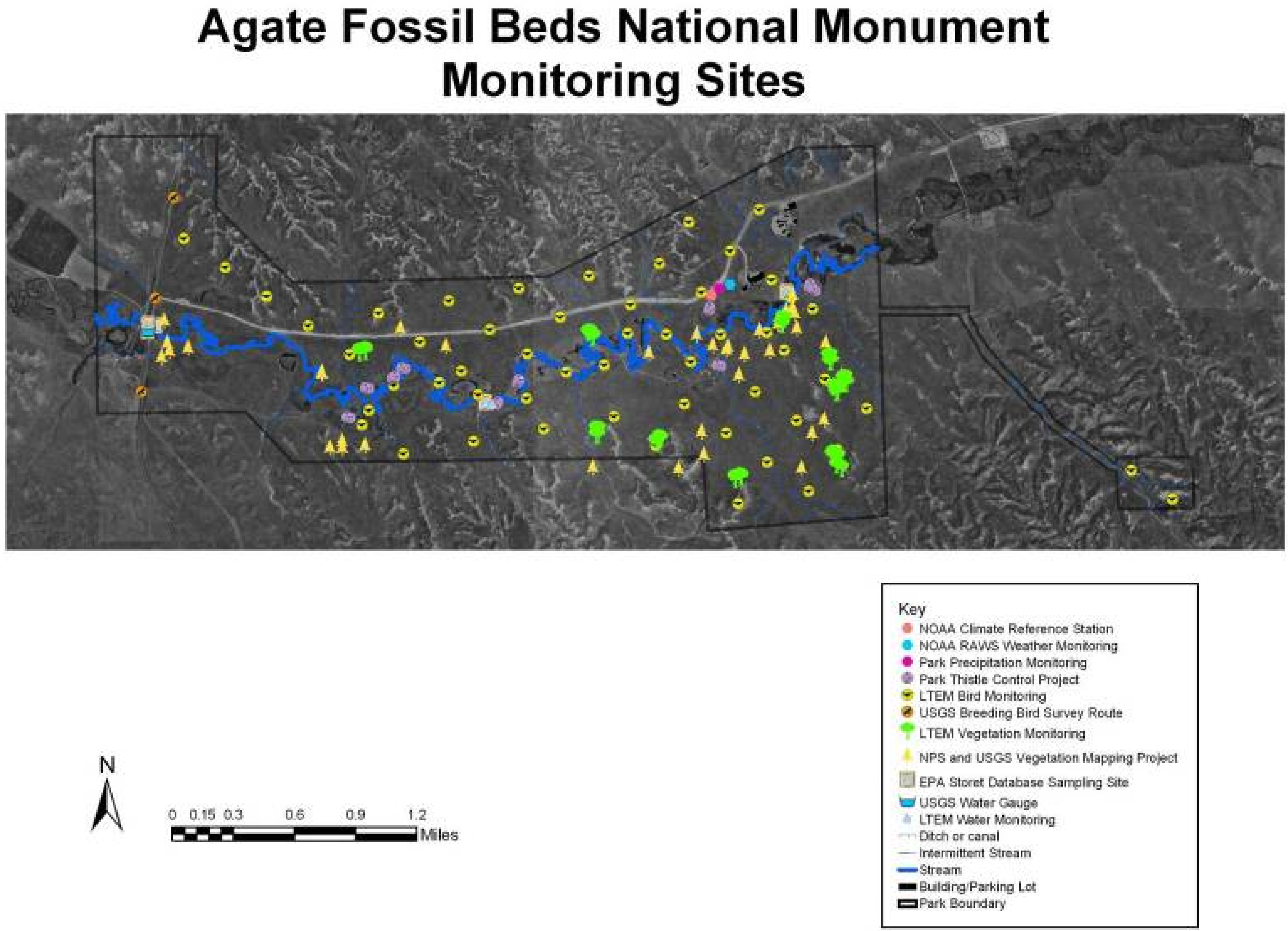

Figure 4. Agate Fossil Beds NM Monitoring and Research Sites

Badlands National Park

ENABLING LEGISLATION/HISTORICAL CONTEXT:
Congress authorized Badlands National Monument in 1929 to preserve the scenic and scientific value of a portion of the White River Badlands for the benefit and enjoyment of the public. The original monument was 111,000 acres. Expansion occurred in 1968 when a Stronghold Unit (a.k.a., South Unit) of 133,000 acres was designated within the Pine Ridge Indian Reservation. Congress intended for the park to manage the site in cooperation with the Oglala Sioux Tribe. An MOA was signed by the park and the tribe in 1976. Also in 1976, a 64,250-acre Badlands Wilderness area was designated within the original portion (a.k.a. North Unit) of the park. The monument was re-designated a national park in 1978. Prior to establishment of the park some of the land, particularly the flat tablelands, were plowed and/or hayed by homesteaders. The remainder of the site was likely grazed by cattle. Cattle grazing continued in parts of the North Unit until a fence was built in 1963 and bison were re-introduced.

PARK MISSION:
Badlands National Park preserves a diversity of significant resources for the education and inspiration of a world audience. These resources are a blending of the best known Oligocene fossil deposits contained within archetypical Big Badlands formations, a rich and varied cultural history spanning from paleo-Indian occupation through the early twentieth century homesteading period, and a fine expanse of a mixed grass prairie ecosystem. Other qualities, most notably the wilderness character, clean air, quiet, solitude, vastness, and natural processes, provide visitors with a setting for exploration and appreciation through such experiences as hiking, camping, wildlife viewing, scenic drives and vistas, research and educational opportunities, and quiet contemplation (from park GMP, in prep).

GENERAL DESCRIPTION:
Located in sparsely populated southwestern South Dakota, Badlands National Park consists of 242,756 acres of sharply eroded buttes, pinnacles, and spires interspersed with the largest protected mixed-grass prairie in the United States. The park has two distinct management units; they are the North and South Units. The South Unit, within the Pine Ridge Indian Reservation, is comprised of the Stronghold Unit and the disjunct Palmer Creek Unit. The North Unit receives by far the highest visitor use and is where most of the administrative and developed areas occur (primarily at the east end of the Unit). The Badlands Wilderness area in the western portion of the North Unit covers 64,250 acres, and is generally sympatric with the range of the park's bison. The wilderness area is commonly recognized as the largest protected roadless area in the Great Plains. The South Unit is managed cooperatively with the Oglala Sioux Tribe. The South Unit is extremely rugged with poor access, although motorized vehicles are allowed on the few dirt roads in the unit. The Palmer Creek Unit is undeveloped and mostly inaccessible. Most visitors experience the park from the main east-west road in the North Unit. Some hiking occurs, primarily during the summer months. Remote camping is allowed in the wilderness Area. Two designated campgrounds are established in the North Unit. Hunting and trapping are not allowed except in the South Unit, which is open to hunting and trapping by tribal members. There are no fishable waters within the park. The tiny town of Interior (pop. 77) is located just outside the southeast corner of the North Unit. There are few tourism related industries in the town. Cattle and horse grazing continue in the South Unit under leases that are generally administered by the Bureau of Indian Affairs and the Oglala Sioux Tribe.

DESCRIPTION OF NATURAL RESOURCES:
The land cover of Badlands NP is noteworthy for the large expanses of barren areas. Approximately 46% of the park has been mapped as barren with an equal amount mapped as native prairie (Von Loh et al. 1999: see Table 4). These barren "badlands" areas, along with the associated fossils, are widely viewed as the most significant natural resources in the park. However, the mixed-grass prairie ecosystem is also widely recognized as significant, especially in recent times. Park staff consider the clean air, natural night sky, and prairie soundscape as significant

resources. At a regional scale, the park is significant because of the large prairie dog complexes, bison grazing, and the use of fire in maintaining the ecosystem. The endangered black-footed ferret makes the park globally important.

Von Loh et al. (1999) used the National Vegetation Classification System (NVCS) to identify 32 vegetation types in the park. Most of the park falls into either the *Badlands Sparse* (46%) or *Western Wheatgrass Herbaceous* (36%) vegetation alliance. Seven of the vegetation types mapped at the park are globally vulnerable or worse: *Green Ash / Elm Woody Draw; Sand Sage / Prairie Sandreed Shrubland; Switchgrass Wet-Mesic Tallgrass Prairie; Prairie Sandreed / Sedge Prairie; Ill-Scented Sumac / Thread-Leaved Sedge Shrub Prairie; Prairie Cordgrass / Sedge Wet Meadow;* and *Common Rabbitbrush / Bluebunch Wheatgrass Shrubland*. Other vegetation types are considered important by park staff, but were too small to be captured by the mapping effort. These include plant communities around the CCC Springs on the west edge of the North Unit and the scattered juniper slumps within the badlands formations. Although 98% of the park's area is in vegetation types characterized by native species; previous land use, invasion by non-natives, and alteration of the grazing and fire regimes have taken their toll on the integrity of the plant communities. In particular, some non-natives—such as annual brome grasses and yellow sweetclover—are pervasive throughout many vegetation types in the park. In addition, approximately 8,000 acres of Canada thistle have been mapped in the park. Areas that were plowed in the past have recovered to mostly native vegetation; however, the diversity of plant species in those areas may be lower than that of unplowed areas. Despite these problems, most of the park's plant communities are relatively healthy. For a more information on plant resources at the park see Symstad (2004).

Badlands NP still contains many wildlife species associated with the Northern Great Plains, including several species that are often missing in outside the park. For example, bison were reintroduced in 1963 and now number 500-700 animals. Bighorn sheep were reintroduced in 1964 and number 50-100. The endangered black-footed ferret was reintroduced to the park and adjoining national grasslands in 1994 and swift fox were reintroduced in the fall of 2003. Mountain lions have apparently re-colonized the park on their own accord. The only mammal species historically found in the vicinity of the park, but now absent are the wolf, grizzly bear, and elk (however, the latter is common 60 miles to the west). Coyote densities are very high. Cattle still graze in the South Unit.

No federally-listed threatened or endangered plant species occur in the park, but the park does support six species on the South Dakota rare plant list. They are Barr's milkvetch, silver-mounded candle flower, Dakota buckwheat, sidesaddle bladderpod, Easter daisy, and largeflower Townsend-daisy. For the most part these species occur in the badlands sparse vegetation type, with Dakota buckwheat being an exception. Of these six, only Barr's milkvetch and Dakota buckwheat are considered globally vulnerable and endemic to the area. The park supports less than a dozen individuals of the federally-listed endangered black-footed ferret; however, the park population is part of the Conata Basin recovery area which now supports several hundred ferrets. Bald eagles are occasionally observed in the park, but do not nest there. Several state-listed animal species are found in the park including the regal fritillary and Dakota skipper butterflies, the swift fox and mountain lion, and one species of fish.

Except for the 3.7 miles of the White River which traverses a small portion of the South Unit, permanent natural surface water is non-existent (USGS National Hydrography Dataset: see http://www1.nrintra.nps.gov/wrd/dui/). Although there is an extensive network of drainages (about 719 miles worth), they are usually dry. Some drainages, such as Sage Creek, support emphemeral surface water and can experience flood events. A few springs also provide surface water at varying rates. The park maintains some impoundments for bison and others exist as a legacy of past use. The cumulative surface area of impoundments in the park is 115 acres (USGS National Hydrography Dataset).

The multi-colored needles, razor-thin ridges, and wrinkled slopes of the badlands geologic formation are a significant park resource. These formations continue to change under the forces of erosion; some sites may erode an inch a year. Within these geologic features are some of the world's richest Oligocene epoch fossil beds, dating 23 to 35 million years old. Paleontological studies continue to this day. The Badlands Wilderness is a Class I air quality area. Visibility at the park has worsened from 1990 to 1999 due primarily to sulfates and nitrates (Pohlman 2005).

NATURAL RESOURCE GOALS AND OBJECTIVES:
According to a GMP currently being prepared, the purpose of the park is to:

- Protect the unique landforms and scenery of the White River Badlands for the benefit, education, and inspiration of the public

- Preserve, interpret, and provide for scientific research the paleontological and geological resources of the White River Badlands
- Preserve the flora, fauna, and natural processes of the mixed-grass prairie ecosystem
- Preserve the Badlands Wilderness Area and associated wilderness values
- Interpret the archeological and contemporary history of use and settlement of lands within the park, with special emphasis on the history of the Sioux Nation and the Lakota people

The goals can be refined into more specific objectives for natural resources (B. Kenner, pers. comm.):

- Preserve and/or restore the native mixed-grass prairie plant communities through invasive non-native plant control, seeding with native seed, native ungulate grazing and wildland and prescribed fire.
- Restore bighorn sheep populations to levels sufficient for long-term viability.
- Restore black-footed ferrets to self-sustaining population as part of the Conata Basin/Badlands Recovery Area; restore prairie dog communities to pre-European levels and complexity.
- Manage the bison herd, within constraints of available habitat, in as close an approximation of a free-ranging herd as possible throughout all habitats in the park. Remove animals from the herd only when necessary, and in a manner that preserves genetic diversity, age classes, and appropriate sex ratio of the herd.
- Monitor, long-term, key indicators of ecosystem health; manage data and conduct analysis to provide a scientifically sound basis for management decisions.
- Conduct a comprehensive park-wide survey of significant fossil resources. Preserve in situ where appropriate, and salvage, preserve and curate in an appropriate storage facility where necessary.
- Manage Native Americans traditional uses of the South Unit to protect ecosystem integrity.

NATURAL RESOURCE ISSUES:

A significant natural resource issue for the park is the confusion and uncertainty in regards to management authority and direction of the South Unit. The park and the tribe are currently negotiating a new MOA. Due to the contentious nature of the relationship, most park operations have been suspended within the South Unit and the park natural resource program is focused primarily on the North Unit.

Non-native plants such as Canada thistle, common mullein, tamarisk, crested wheatgrass, Kentucky bluegrass, smooth brome, and yellow sweetclover are a severe problem in the North Unit (Badlands National Park 2003). Controlling these species is a high management priority. The park uses fire to control expansive stands of exotic plants and to meet other management goals (Badlands National Park 2004: the park would like to expand the fire program to include all burnable areas in the park). The park uses herbicides and biological control for some exotics.

The park has numerous wildlife issues and needs. The park has an active base-funded ferret program; however, ferret numbers remain low within the park. The park currently supports over 6,000 acres of black-tailed prairie dogs; the park would like to increase the acreage in part for ferret recovery. However, prairie dog management is contentious with neighbors and requires significant time of park staff. Bison management requires significant attention as well because surplus animals need to be culled annually to maintain the population at desired levels. There are concerns about this practice on herd genetics and viability. The park would like to expand the bison herd to all suitable habitats in the park (including the South Unit). There is desire by park staff to increase the density of bison within the current range; however, the limited surface water precludes population increases. The park would like to remove cattle from the South Unit and replace them with bison; however, the Oglala Sioux Tribe has yet to agree to the change. Significant amounts of park resources and time are spent managing the small bighorn sheep population. Sheep reintroductions have occurred periodically to augment the park's population (most recently in 2004). Poaching continues to be a concern, especially in the South Unit.

Aquatic resource issues are minor compared to other resources; however, there are a few noteworthy exceptions. The White River is a 303(d) water impaired by pathogens and suspended solids. Park staff are concerned about water quality of the CCC Spring in the west portion of the North Unit. This spring originates on private lands that receive high loads of pesticides and fertilizers. The park is concerned about the ecological impacts of the manmade stock ponds within the bison range. The park would like to reduce the number of maintained ponds to the minimum needed for bison watering, but the park currently lacks information on what sites should be maintained and which ones should be restored to natural drainages.

Maintaining wilderness values such as clean air and natural vistas and soundscape is an important goal for the park. Air quality is a concern due to energy development in Wyoming. A proposed rail line along the west side of the park may also affect air quality, the soundscape, and other resources. Climate change may affect natural resources in the park. For example, many mesic plants in the park are on the periphery of their range and at the extreme of their tolerance levels in the hot dry climate of the park. More visitors and the potential for increased bed-and-breakfast establishments around the park boundary are all issues of concern to park staff. Trail rides, a potential Rails-to-Trails project along Highway 44, and helicopter tours are also of concern to park staff. Although not directly a resource issue, the park has a desire to continue to integrate and coordinate its management activities with the adjoining Buffalo Gap National Grasslands. The two agencies already have a close working relationship in regards to ferrets, prairie dogs, and swift fox. Last, the park expects several opportunities to expand the park boundary and/or acquire inholdings within the current boundary. Park staff would like to be in a position to monitor and track changes to these potential acquisitions. At the time of this report the park recommended not monitoring in the South Unit due to continuing negotiations with the tribe concerning access and administration of the unit.

PARK-SPECIFIC MANDATES AND REQUESTS TO MONITOR NATURAL RESOURCES:
Implicit in the park's legislative history is the mandate to protect and monitor fossil resources. The Badlands Wilderness is a Class I air quality area so the park must monitor air quality at the site.

CURRENT MONITORING PROJECTS:
Badlands NP has a comparatively well-staffed natural resource program. That, combined with the park's emphasis on natural resources and the value of the site to the scientific community, has resulted in numerous studies. However, long-term monitoring efforts are comparatively few. Vegetation monitoring is conducted within burn units by the NGP Fire Effects Program. The small size of the program, combined with the large size of the park, greatly limits the scope and effectiveness of that monitoring program. The NGP EPMT collects some information on the density and distribution of exotic plants as a part of their control operations. Numerous other vegetation studies, including studies on rare plant distribution and herbivory, have been initiated at the park and could provide a baseline for future monitoring. Several ungulate and/or prairie dog exclosures exist in the Badlands Wilderness area; however, their integrity has been compromised and they are not easily accessible.

The park has numerous wildlife monitoring projects. The park conducts a Christmas bird count and runs a Breeding Bird Survey route. Park staff monitor for burrowing owls. In regards to mammals, the park anually censuses the bison herd, typically using a ground count. During the roundups and herd reductions park staff collect information on population structure, genetics, and disease. Swift fox, ferrets, prairie dogs, and bighorn sheep demographics are all monitored using a variety of methods. The State of South Dakota flies the park as part of its pronghorn surveys. In the South Unit the Oglala Sioux Tribe runs a transect survey for estimating deer density. Park staff periodically live capture coyotes and test them for plague, distemper, parvovirus, and other diseases. The park regularly puts out gypsy moth traps. Several years of butterfly surveys have been conducted by park staff.

Studies have been conducted in the park in regards to water quality and quantity, but there is no regular monitoring other than for drinking water. The park has a good air quality monitoring program. An IMPROVE air quality monitoring site is located near the park headquarters along with monitors for sulfur and nitrogen oxides, continuous ozone, and particulates (some of this is funded by the State of South Dakota). Visibility monitoring is conducted. Weather stations are located at the headquarters site as well as the Pinnacles and White River Ranger Stations (the latter two are primarily for fire monitoring). Some monitoring of paleontological resources can be inferred from law enforcement activities; however, park staff feels that the current level of monitoring does not meet NPS expectations. Pesticide application in the park is closely monitored per NPS requirements, but there is no monitoring of residual levels. Baseline sound monitoring data was collected in 2004 for an air tour management plan and other studies were conducted in the early and mid 90s, but no current sound monitoring is occurring. A complete list of past and current monitoring and replicable research efforts in and near the park can be found in Appendix D.

ADDITIONAL INFORMATION:
Detailed information on the park can be found at http://www.nps.gov/badl/index.htm and other NPS web sites, in Cerney (2004), and in the park's General Management Plan.

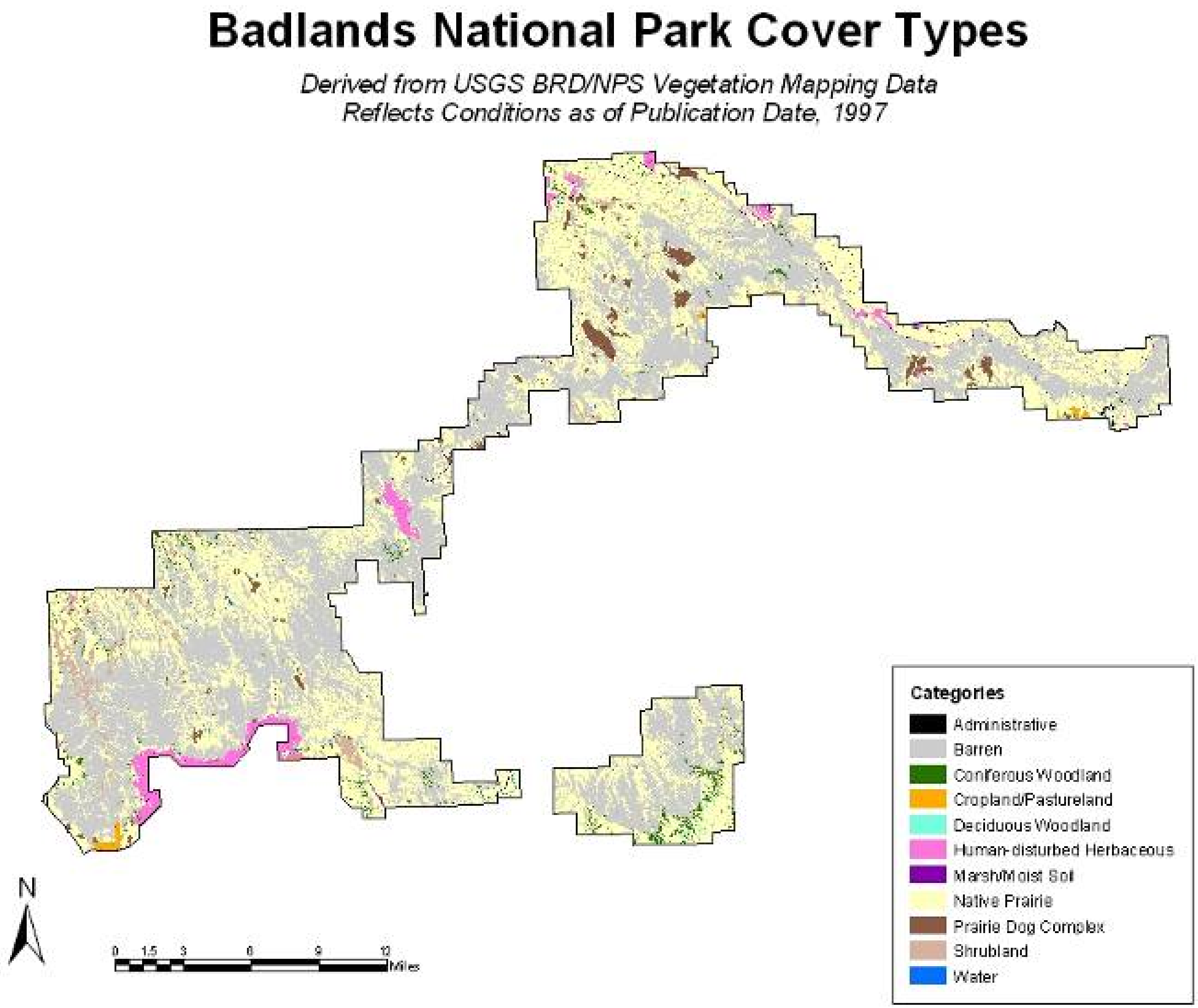

Figure 5. Badlands NP Land Cover

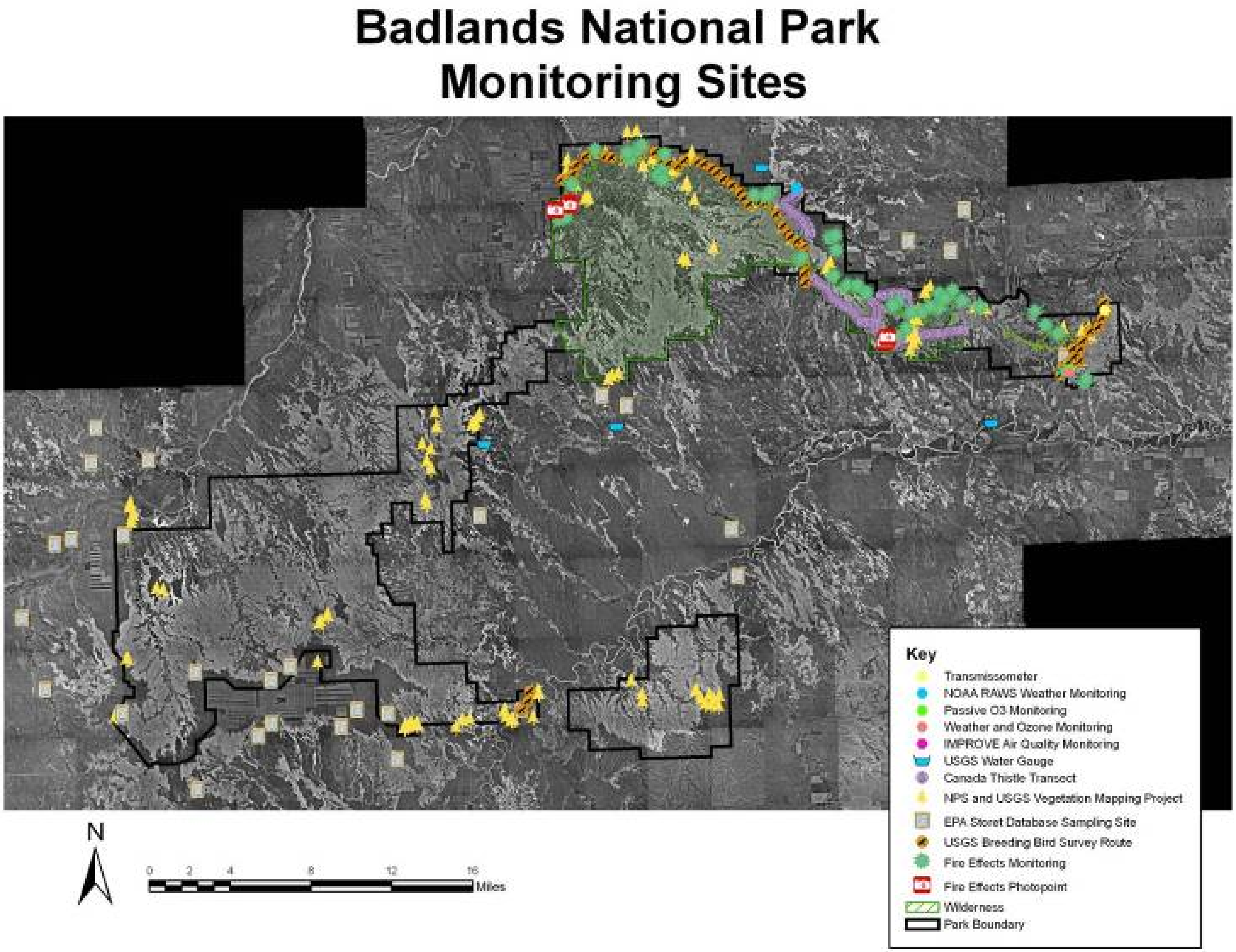

Figure 6. Badlands NP Monitoring and Research Sites

Devils Tower National Monument

ENABLING LEGISLATION/HISTORICAL CONTEXT:
Devils Tower NM was established in 1906 as the nation's first national monument under the Antiquities Act. The proclamation stated that the site was "a natural wonder and object of great scientific interest" and that the park shall "reserve, preserve, and protect the lofty isolated rock and surrounding reserved public lands as an object of historic and scientific interest for the public benefit." A minor boundary change occurred in 1955.

PARK MISSION:
The park's General Management Plan (GPM: Devils Tower National Monument 2001) identified four mission goals for the park. They are:

- Restore and maintain the health and diversity of the monument's natural systems.
- Preserve archeological, historic, and ethnographic values at Devils Tower.
- Interpret the significant and varied themes of Devils Tower.
- Balance educational, spiritual, and recreational uses of Devils Tower and its surrounding landscape to provide meaningful visitor experiences.

GENERAL DESCRIPTION:
Devils Tower NM is located in northeastern Wyoming, just northwest of the Black Hills (in a region known as the Bear Lodge Mountains). In the center of the 1,347-acre park is Devils Tower (Tower), a monolith made of igneous rock with many symmetrical joint columns. At 867 feet high, and 1,267 feet above the Belle Fourche River, the Tower is a dominant landmark in the region, and the primary feature of the park. The Tower is sacred to many Native Americans and figures prominently in their belief systems and narratives. At least 20 tribes are known to have a cultural affiliation with the Tower. The Tower is also one of the premiere rock climbing areas in North America. Several thousand climbers attempt to scale the Tower each year. The park carefully regulates and manages climbing activities. Hunting and trapping are not allowed at the park, but do occur just outside the boundary.

DESCRIPTION OF NATURAL RESOURCES:
Approximately 58% of the park consists of forest (primarily ponderosa pine) and another 30% is native prairie (Salas and Pucherelli, 1998*a*: see Table 4). However, it is the Tower that dominates natural resources and resource management at the park. Other noteworthy natural resources include the Belle Fourche River and its riparian forest and a 40-acre prairie dog colony.

The vegetation of the park was mapped according to NVCS standards in 1996-1997, yielding seventeen vegetation types in the park (Salas and Pucherelli, 1998*a*). Four of these are considered globally vulnerable or worse, but the ranking is certain for only the *Ponderosa Pine / Bur Oak Woodland*. The other three are *Ponderosa Pine/Oregon Grape Forest*, *Ponderosa Pine / Bluebunch Wheatgrass Woodland*, and *Prairie Cordgrass / Bulrush Wet Meadow*. Five other vegetation types may also be vulnerable. The Black Hills Community Inventory (Marriot et al. 1999) evaluated the condition of all seventeen vegetation types mapped at the park. One of these (*Black Hills Granite / Metamorphic Rock Outcrop*) was ranked as "A" (where A has the highest integrity on a scale of A to F), ten others as "AB", two as "B", and the remaining four as "BC" or "C". Because of the good condition of many of the plant communities the park was considered a possible exemplary site by the study; however, the small size of most of the communities and the poor condition of the riparian vegetation types precluded the park's inclusion as an exemplary site. In the riparian areas a disrupted flood regime and perhaps herbicide residue have resulted in a lack of recruitment of cottonwood. Exotic species, particularly leafy spurge, are also a problem in the riparian zone. In the uplands, annual brome grasses, houndstongue, common mullein, bulbous bluegrass, and Kentucky bluegrass are problematic. Kentucky bluegrass is particularly widespread in grassland areas and is dominant in one of the vegetation types. The top of the Tower supports a small grassland community. It is not known if any of the plants or animals on top of the Tower are genetically unique or otherwise significant. For a more thorough discussion of plant resources at the park see Symstad (2004).

The 40 acres of prairie dogs are considered the most prominent wildlife resource at the park in terms of visitor appreciation and ecological significance. Park personnel believe there is a high density of porcupines at the park; whether they are unnaturally high is not known. Prairie falcons nest on the Tower and are a significant wildlife resource because of their uniqueness, appreciation by the public, and potential conflict with climbing activities. Peregrine falcons have been observed, but are less common. White-throated swifts are another species of concern that uses the Tower. There is the potential for goshawk nesting in the park. The late-succession pine forest and the riparian deciduous forest provide valuable bird habitat (Panjabi 2005) and are important for bats (Schmidt et al. 2004). Smith et al. (2005) estimated that 16-17 species of herpetofauna use the park. Shorthead redhorse, smallmouth bass, and white sucker were the most common fish species captured in the Belle Fourche River (White et al. 2002). At least 67 butterfly species have been documented, although the actual number present might be closer to 90 (Opler and Garhart 2004).

The park has no resident federally-listed threatened or endangered plant or animal species. Six species on the current Wyoming list of Plants of Special Concern (http://uwadmnweb.uwyo.edu/wyndd/Plants/plant_species.htm) occur at the park (Fertig 2000). However, all of these are considered globally secure; they are on the state list primarily because they are on the periphery of their range (see Symstad 2004). One of the six (whorled milkweed) has its only known Wyoming occurrence at the park. Bald eagles are occasionally observed in the vicinity of the park and sometimes winter there, but are not known to nest there. Whooping cranes may occasionally fly over.

About 0.8 miles of the Belle Fourche River passes the south side of the park and contributes to the diversity of the site (USGS National Hydrography Dataset: see http://www1.nrintra.nps.gov/wrd/dui/). The river averages about 20 feet in width and is generally knee deep or less. Another 1.1 miles of intermittent drainages occur in the park. Several small springs, some of which are developed, are found in the park. Geologic resources are a significant part of the park. The park is situated on the border of the Red Valley and Hobback geomorphic features. In addition to the Tower, the park also contains a Slot Canyon site that provides a unique micro-community and geologic feature.

NATURAL RESOURCE GOALS AND OBJECTIVES:
The park does not currently have explicit natural resource goals or desired future conditions (except for fire).

NATURAL RESOURCE ISSUES:
Management and protection of the Tower is the primary natural resource issue for the park. For example, the park restricts climbing of the Tower from March 15 to May 1 to provide an opportunity for nesting by falcons, and may extend the closure if nesting is observed. There are also concerns about climber impacts to vegetation and soil on top of the Tower. Climbing can affect the integrity of the Tower (e.g., things falling off, impacts from bolts and hangers, audio impacts).

Exotic plants are a serious management issue at the park. Invasive plants such as leafy spurge have established homogenous stands that have displaced native vegetation. Other exotics such as houndstongue occur in less dense stands, but are more widely distributed. The park has an active exotic plant control program using both within-park resources and the NGP EPMT. The park actively manages for a natural patchiness of meadows and forest in the park. Vegetation health in the Belle Fourche riparian corridor, specifically the loss of natural regeneration of cottonwoods and willows, is a concern to management. It is unclear how much of the lack of tree recruitment can be attributed to the altered hydrograph, to pesticide residue (e.g., Tordon), or other factors. Degradation of the riparian forest will have severe consequences on bird richness and abundance (Panjabi 2005). The primary wildlife issue at the park is the management of the prairie dog town. In recent years the colony expanded into a campground and administrative area; however, that may be less of a management issue in the future since the campground may be abolished. That notwithstanding, prairie dogs will continue to be a management issue due to concerns by neighbors, interactions with visitors, and the potential for a plague epizootic. The latter would be a concern from both the perspective of human health and for viability of the prairie dogs. Deer abundance is currently a lesser concern for park staff; however, exclosures were established at the park to help assess the impacts of deer herbivory. Livestock trespass is an ongoing problem. Protecting the late-succession ponderosa pine is important for bird (Panjabi 2005) and bat (Schmidt et al. 2004) conservation.

Water quality and quantity in the Belle Fourche River is a management issue. An upstream dam has altered the natural hydrograph of the river. Private land south of the river is rangeland which can affect water quality. The river is listed as a 303(d) river impaired by fecal coliform. Herbicide use, from both within and outside the park, may affect water quality. The park has at least three springs; maintaining natural water conditions is a concern to park management. Spring boxes may be compromising habitat for amphibians (Smith et al. 2005). Air quality may become more of an issue due to an increase in energy development further west. The park is currently a Class II airshed. The park would like an air quality monitoring station. Helicopters and small planes flying over the park may affect park resources (e.g., wildlife) as well as visitor experiences. Potential residential and commercial development, especially along the south border, could impact park resources and visitor experiences. Actions proposed in the new GMP, such as a shuttle transportation system within the park, could affect resources.

PARK-SPECIFIC MANDATES AND REQUESTS TO MONITOR NATURAL RESOURCES:
There are no specific mandates or legislation requiring monitoring in the park. Park neighbors would like the park to monitor for chronic wasting disease, West Nile virus, and exotic plants (specifically noxious weeds).

CURRENT MONITORING PROJECTS:
The NGP Fire Effects program uses a systematic plot-based approach to monitor vegetation in burn units within the park. The NGP EPMT regularly maps the distribution of noxious exotic plants and makes a qualitative assessment of density. A vegetation and soil study was conducted on the Tower top in the early 1990s: the study may be replicable. There are deer exclosures within the park that could be use for monitoring the effects of herbivory. Park personnel monitor the Tower in the spring for prairie falcon nesting due to potential conflicts with climbers. Park personnel monitor prairie dog distribution and density using the Plumb et al. (2001) method. Gypsy moth traps are deployed in coordination with the U.S. Forest Service. Park staff test potable water for nitrates and nitrites. Park personnel collect monthly water level readings from 12 wells in the park to determine suitability for cottonwood regeneration and to assess risk of contamination from herbicides. The park has a NOAA RAWS weather station. Pesticide application is tracked using NPS protocols. Audio measurements were collected for an entire year in the mid-1990s and was recently repeated. The project will be replicated one year after the airport is opened. Photo points were established by the Fire Effects and EPMT programs. A complete list of past and current monitoring and replicable research efforts in and near the park can be found in Appendix D.

ADDITIONAL INFORMATION:
Detailed information on the park can be found at http://www.nps.gov/deto/index.htm and other NPS web sites, in Norton (1991) and Mattison (2001), and in the 2001 General Management Plan (Devils Tower National Monument 2001).

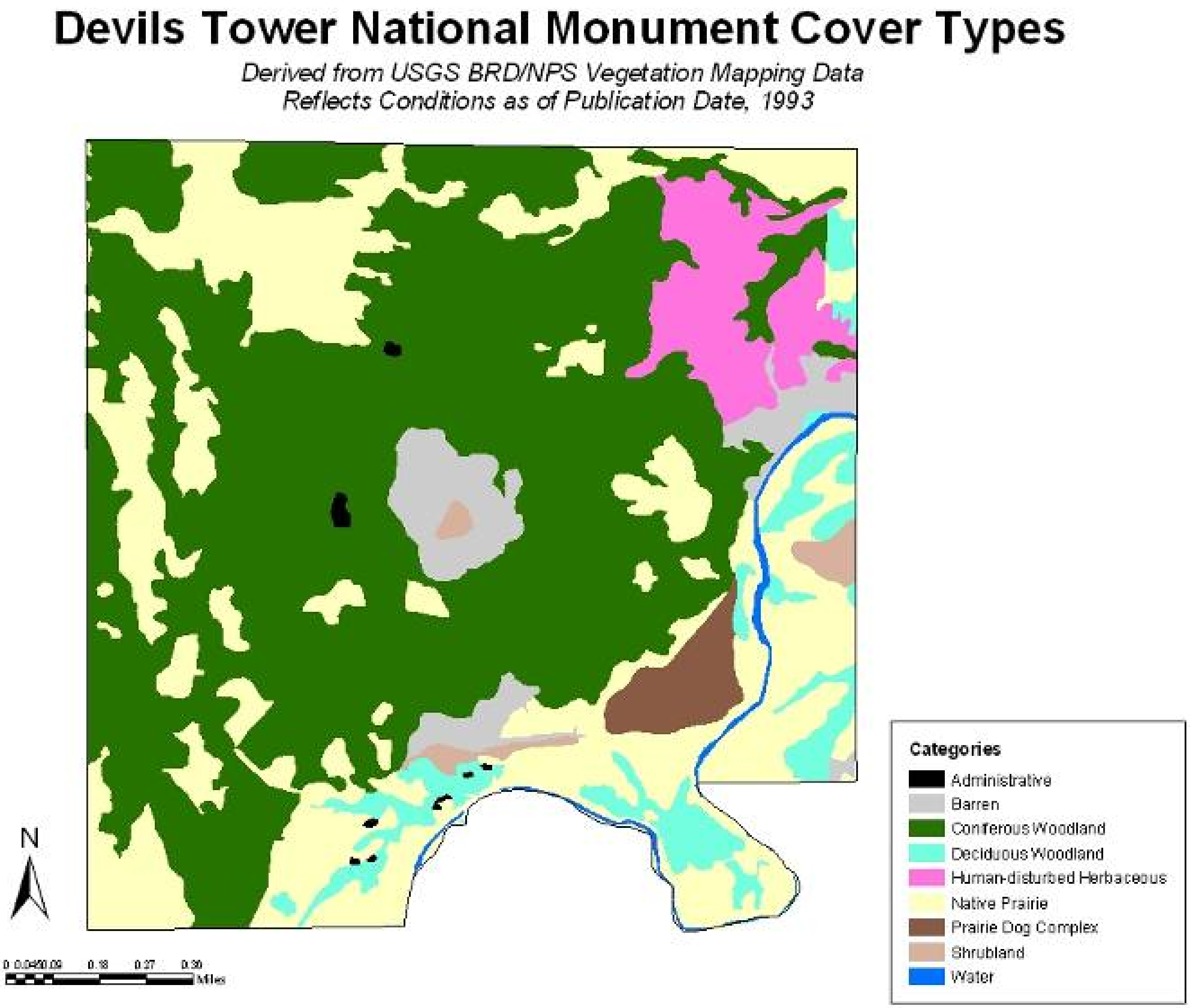

Figure 7. Devils Tower NM Land Cover

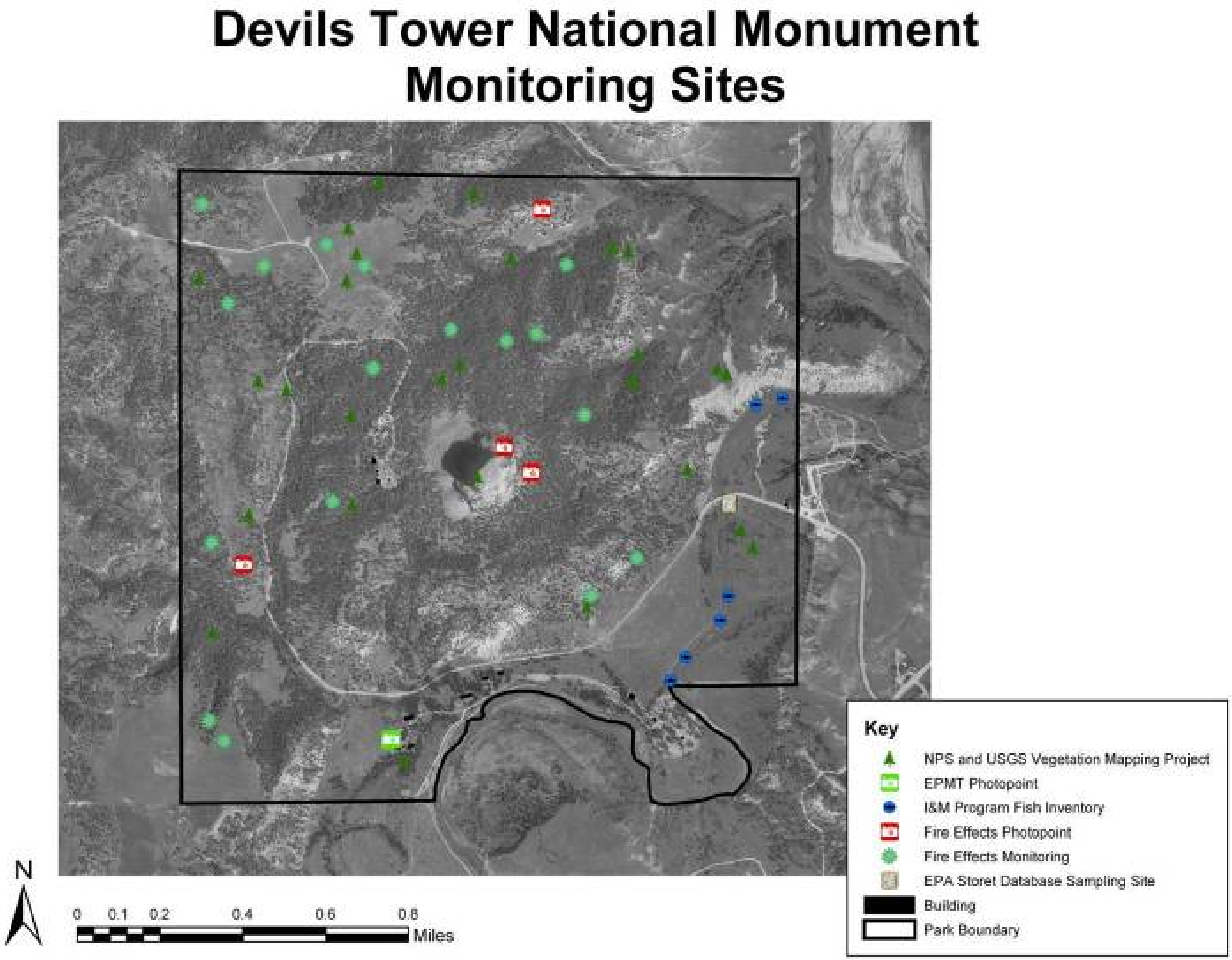

Figure 8. Devils Tower NM Monitoring and Research Sites

Fort Laramie National Historic Site

ENABLING LEGISLATION/HISTORICAL CONTEXT:
Fort Laramie NHS was proclaimed a national monument in 1938 and designated a national historic site in 1960. Boundary changes occurred in 1960 and 1978. The proclamation creating the park said it was established for the purpose of improving, preserving and maintaining such lands and structures as a public historical site. The primary period of historical significance for Fort Laramie was from 1842-1890. Major fur trading posts occurred at the site from 1834-49 and the site was an important military fort from 1849-90. Between the abandonment of the fort in 1890 and the park's establishment in 1960 the area was essentially a country village (Mattes, 1980).

PARK MISSION:
The mission of Fort Laramie National Historic Site is to "preserve and protect for the future its historic landscapes, sites and structures; and to further public understanding and appreciation of the historic events, inter-relationships of cultures, the many personalities of Fort Laramie and northern plains region, the nation's westward expansion and resulting Native American resistance" (National Park Service 2000*a*).

GENERAL DESCRIPTION:
Fort Laramie National Historic Site lies in southeastern Wyoming at the confluence of the North Platte and Laramie Rivers (Scotts Bluff NM is approximately 50 miles downstream). The 833-acre park lies just to the west of the town of Fort Laramie (pop. 243). The park is best known for cultural resources; with the centerpiece being the surviving buildings from the major military post that existed in 1849-90 (buildings from the fur trading post era are destroyed). Park law enforcement personnel assist in monitoring nearby federal properties administered by the Bureau of Land Management (BLM). Although there have been discussions of transferring the site to NPS administration, such transfer does not seem imminent. Hunting and trapping are not allowed at the park, but do occur just outside the boundary. Fishing does occur in the park; however, demand is minor. Surrounding lands are primarily privately owned ranchland and farmland. An irrigation canal runs alongside the south boundary of the park.

DESCRIPTION OF NATURAL RESOURCES:
Fort Laramie NHS has a diversity of natural resources and habitats for such a small site. This is due in large part to the two rivers that meet in the park, the topography that ranges from riverbed to upland areas, and the location of the park near the western edge of the Great Plains and eastern edge of the Rocky Mountains. While native prairie is the largest cover type (41% of the park), significant amounts of human disturbed areas, forest, administrative sites, barren areas, and surface water are also present (Aerial Information Systems, 1998*b*: Table 4).

The natural vegetation of the area includes short- and mixed-grass prairie and riparian floodplain forest (Jones and Tebben 2002). In 1996-97 the park's vegetation was mapped according to NVCS standards (Aerial Information Systems, 1998*b*). Thirteen vegetation types were identified, two of which may be globally vulnerable or worse: they are the *Cottonwood / Western Snowberry Woodland* and the *Prairie Cordgrass-Bulrush Wet Meadow* types. One additional vegetation type, *Western Wheatgrass Mixed-grass Prairie* may be globally vulnerable, but its current status is not well understood. At least 25% of the park was classified in one of three disturbed vegetation types. Historical records and current vegetation suggests that the majority of the park's non-riparian acreage was cultivated and/or severely grazed at one time. Restoration has been attempted in some of these areas, but the success of these efforts has not been quantitatively assessed. Exotic and invasive species such as cheatgrass, Japanese brome, smooth brome, kochia, and Canada thistle are common. Riparian vegetation along the Laramie River is generally in better condition (i.e., fewer invasive plants, more cottonwood regeneration) than along the North Platte River. A plant inventory conducted in 2003-04 documented seven species in the park that are on the Wyoming Natural Heritage Species of Concern list (Heidel 2004). For a more thorough discussion of plant resources at the park see Heidel (2004) and Symstad (2004).

Current wildlife resources are typical of the area; however, some species in the park may be at the edge of their range (Schmidt et al. 2004). The park has no native grazing ungulates, but it does support year-round pasture for 4 equines and provides winter (September - April/May) pasture for about 28 equines from Rocky Mountain National Park. Stocking rates were developed by the county based on park objectives. White-tailed deer are very common, especially in the riparian areas; mule deer are occasional. The park built a bat house for the purpose of keeping bats from occupying the historic structures: the bat colony is now one of the more widely promoted natural resources within the park and is important to regional biological diversity. Panjabi (2005) reported high bird richness and density in the riparian areas including an abundance of red-headed woodpeckers, a species of concern. The two rivers remain open in the winter months, thereby attracting waterfowl and raptors in comparatively large numbers. Smith et al. (2005) estimated that herpetofauna richness could be as high as 18 species. At least 21 fish species occur in the park, with white and longnose suckers being the most abundant (White et al. 2002).

No federally-listed endangered and threatened species reside at the unit year round. Ute ladies'-tresses occurs in the region, but surveys along the Laramie River in the park did not locate it and the habitat along the North Platte River is not suitable (National Park Service, 2003, Heidel 2004). Bald eagles are common during migration, but are not known to nest in the park. The park has habitat for the threatened Preble's jumping mouse, however, a 2003 mammal inventory failed to locate the species (Schmidt et al. 2004).

The two rivers are significant natural resources within the park. The combined length of the perennial rivers in the park is 2.5 miles while another 1.4 miles or river abut the park (USGS National Hydrography Dataset). Water clarity is fair to good and the substrates are gravel and cobble. River oxbows are present. However, the hydrology of the rivers and subsurface water has been greatly altered due to upstream dams, irrigation withdrawals, canal seepage, and other factors.

NATURAL RESOURCE GOALS AND OBJECTIVES:

The park's GMP discusses broad natural resource management goals, calling for practices that "reestablish and promote native plants and animals that contribute to and create the park's historic scene, to the greatest degree possible" (National Park Service 1993:4).

NATURAL RESOURCE ISSUES:

At the time of European settlement the site where the park is located looked dramatically different. For example, the Platte River was a murky river with high suspended-sediment loads typical of many Great Plains streams. In contrast, the Laramie River was more of a clear mountain stream. The valley near the confluence of the two rivers was mostly devoid of trees and sagebrush. The few cottonwoods that did exist in the area were quickly cut down by settlers (Lavender 1983). Restoring and maintaining the natural scene and conditions from the historic period is a high priority to park staff.

Exotic plants, including trees, forbs, and grasses, continue to be a significant management issue in all habitats in the park (Jones and Tebben 2002). Since 2002 EPMT has actively sought to control the exotics, but there is no systematic monitoring of the effectiveness of the program. Furthermore, some control actions may affect other resources such as bird communities (Panjabi 2005). Native tree recruitment in the riparian forest may be threatened due to a decrease in flood events and the high deer densities. The absence of fire in the uplands remains a concern to park staff. There are concerns about the level of horse grazing and the impact it is having on resources such as butterflies, herpetofauna, and mammals (Opler and Garhart 2004, Schmidt et al. 2004, Smith et al. 2004). Canada geese numbers have increased and may be at unnaturally high levels and/or having impacts on park resources. Brown trout and carp are exotic species that are present in the rivers (White et al. 2002). Chronic wasting disease and West Nile virus are of concern to management. The potential occurrence of the federally-listed Preble's meadow jumping mouse (currently proposed for de-listing) will remain an issue.

The dams on the Laramie and North Platte Rivers continue to impact the riverine ecosystems within the park. The irrigation canal just south of the park affects park resources through seepage and other hydrological affects. The future status of the canal is uncertain. It's also unclear what impact it is having on herpetofauna and other resources (Smith et al. 2005). Herbicides are used both within and around the park, potentially affecting water quality. Nearby power plants may be affecting air quality in the park. In the future there may be increased residential development in the vicinity of the park. The nature trails within the park are being promoted more which may have negative impacts. The park is concerned about the affect of night lights on the night sky and visitor experiences. The park is concerned about the soundscape, especially from a nearby railroad track, National Guard helicopters, and artillery range. Air quality monitoring in the vicinity of the park is considered poor (Pohlman 2005).

PARK-SPECIFIC MANDATES AND REQUESTS TO MONITOR NATURAL RESOURCES:
There are no specific mandates that require monitoring of natural resources. Local governments and others would like the park to monitor (and control) noxious weeds. They would also like the park to monitor for chronic wasting disease and West Nile virus. The Wyoming Natural Heritage Database would like the park to monitor the species on the state Watch list. The Fish and Wildlife Service would like the park to continue to monitor for the presence of the Preble's meadow jumping mouse. The BLM would like the park to continue to monitor the status of the lands near the park (primarily in regards to law enforcement issues).

CURRENT MONITORING PROJECTS:
Very little systematic monitoring occurs at Fort Laramie NHS. Park staff, along with the EPMT, unsystematically monitor the distribution of salt cedar, Russian olive, and other invasive exotics. Noteworthy wildlife observations made incidental to other activities are often recorded. Weather information is collected daily. Basin Electric's Laramie River Station power plant (located upstream on the Laramie River above the Grey Rocks Reservoir) collects water quality data annually in the vicinity of the park. A complete list of past and current monitoring and replicable research efforts in and near the park can be found in Appendix D.

ADDITIONAL INFORMATION:
Detailed information on the park can be found at http://www.nps.gov/fola/index.htm and other NPS web sites, in the park GMP and amendment (National Park Service 1993, 2000*a*), and in Lavendar (1983).

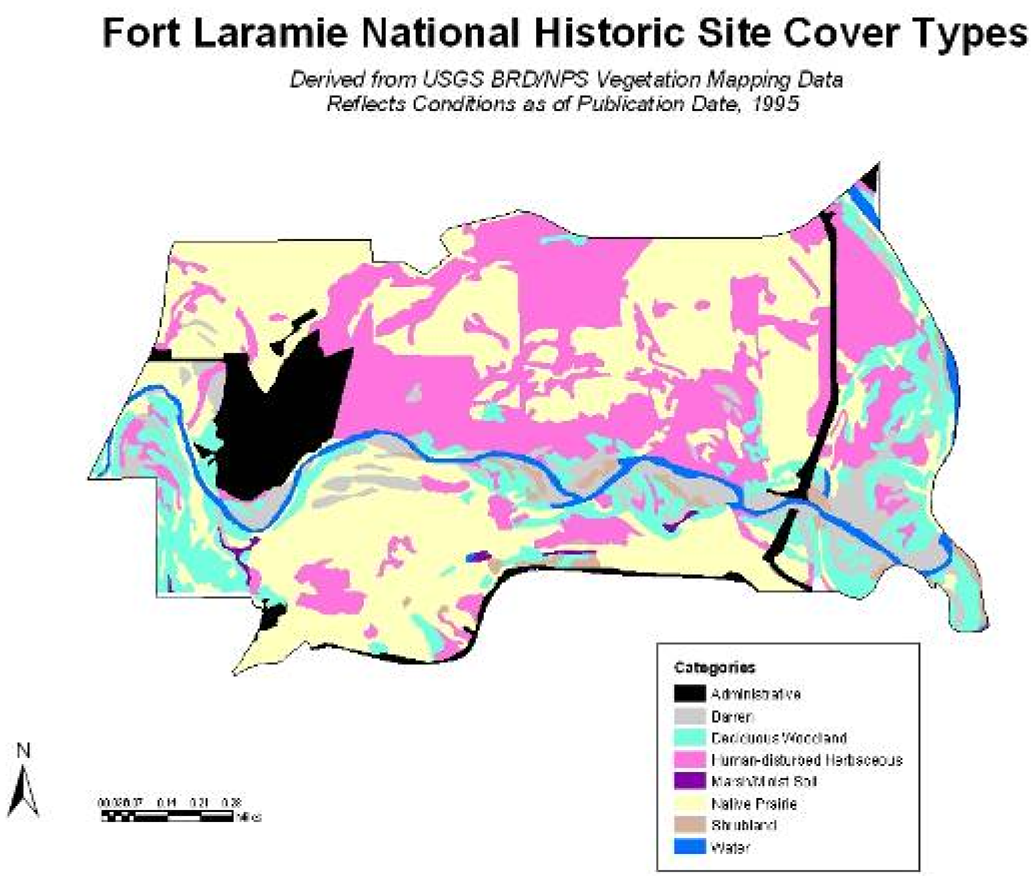

Figure 9. Fort Laramie NHS Land Cover

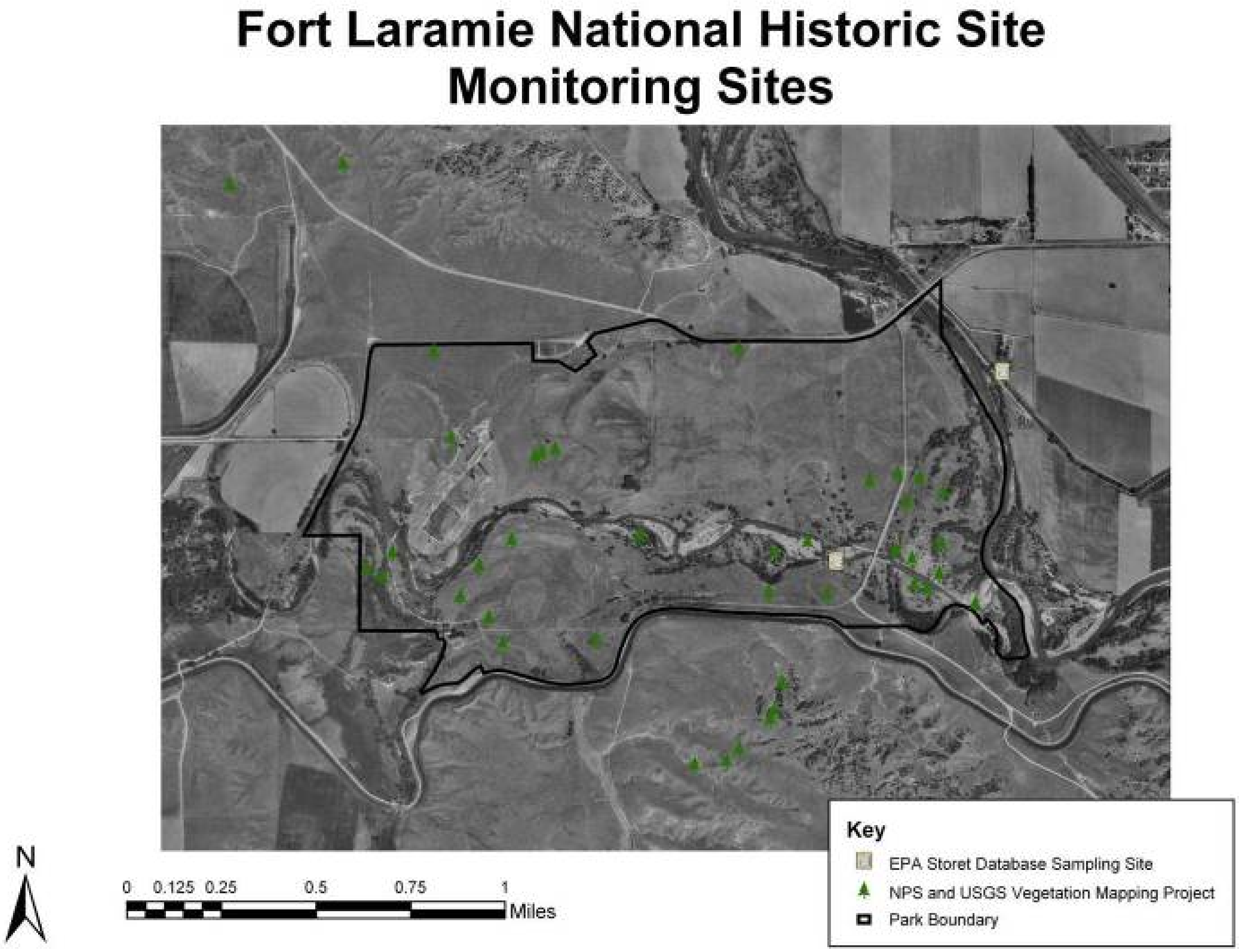

Figure 10. Fort Laramie NHS Monitoring and Research Sites

Fort Union Trading Post National Historic Site

ENABLING LEGISLATION/HISTORICAL CONTEXT:
Fort Union Trading Post NHS was authorized in 1966 with a boundary change in 1978. The park was created to commemorate the trading post which operated from 1828-1867. In 1867 the U.S. Army bought the post and removed much of the building materials. The site was subsequently occupied by a Hidatsa band for about 15 years. From 1941 to 1966 the site was administered as a state park.

PARK MISSION:
The park's mission (from the 1999 GPRA goals) is: "Fort Union Trading Post tells the story of the preeminent American fur trading post on the upper Missouri River. Fort Union contributed significantly to the history of exploration, transportation, economics and sociology of the American frontier in the early-mid 19th century. Most important, as a point of interaction between Euro-Americans and Plains Indians, Fort Union's history focuses on the complimentary relationship between the two cultures."

GENERAL DESCRIPTION:
The 442-acre Fort Union Trading Post NHS straddles the Montana/North Dakota border with most of the park in the latter. The park is bisected by the Missouri River just upstream of its confluence with the Yellowstone River. A large portion of the trading post has been reconstructed to the 1850s condition. Cultural resources are a primary feature of the park. Hunting and trapping are not allowed, but do occur outside the boundary. Surrounding lands are primarily private ranch and farmlands. Gas exploitation occurs in the vicinity. The nearest large town is Williston ND (pop. 12,512), about 25 miles to the northeast.

DESCRIPTION OF NATURAL RESOURCES:
The two most significant natural resources to park management are the river and the prairie; however, the river channel per se is not within park jurisdiction. The land within the park boundary is comprised of two distinct vegetative zones: the ancient upper floodplain on which the fort is located, i.e., the prairie, and the lower and sometimes flooded forested floodplain along the Missouri River. About 46% of the park is in human disturbed sites (e.g., previously cultivated areas) and 7% consists the fort and other infrastructure (Salas and Pucherelli, 2003*a*), making the park one of the most anthropogenically altered units in the Network (see Table 4).

The potential natural vegetation of the area is riparian floodplain forest in the lower terrace and northern mixed-grass prairie in the uplands. Historical photographs and paintings suggest that there were few trees on the park side of the Missouri River (i.e., the north side), but its unclear how much of this was natural and how much was due to cutting of the trees. The historical documents show extensive forests in the floodplains on the south side of the river. Nowadays, thick stands of trees and shrubs interspersed with marsh and willow thickets occur only throughout the active floodplain; however 25% of the south unit is now devoid of trees due to historic cultivation. Dominant species include cottonwood, ash, elm, and sedge (Willard 1980). The upland area (i.e., the ancient floodplain) is generally a mixture of native and exotic grasses. Prior to park establishment the site was farmed. It is now being restored to native prairie vegetation. The Bodmer Overlook—a 40-acre parcel that overlooks the fort from the north—is less disturbed and is primarily native vegetation. Dominant species at the site include needle-and-thread, western wheatgrass, blue grama, and prairie coneflower (Willard 1980, Godfread 2004). Of the fourteen vegetation types mapped at the park, only the *Green Ash – Elm Woody Draw* type is ranked as globally vulnerable (Salas and Pucherelli 2003a). That report also stated that the understory forb layer in the community had a considerable amount of exotics including smooth brome, Kentucky bluegrass, alfalfa, and crested wheatgrass. For a more thorough discussion of plant resources at the park see Godfread (2004) and Symstad (2004).

The mixture of woodland and prairie vegetation provides habitat for a variety of animals. Deer are common, but do not seem overabundant. About 90% of the bird richness is in the riparian forest (Panjabi 2005). Likewise, herpetofauna richness is high in the forested riparian area (Northern leopard frog density appears to be exceptionally high) and low in the prairies (Smith et al. 2005). Mosquitoes are noted as being particularly nettlesome at the park; a condition which was observed along the Missouri River as far back as Lewis and Clark. Many large mammals, including wolf, bison, elk, mountain lion, and bear are extirpated from the site (Schmidt at al. 2004). It's likely that some invertebrates have been extirpated from the site as well and the future of others is in jeopardy (Royer 2004). The park has no federally-listed threatened or endangered plants. So far, the only plants on the North Dakota Natural Heritage Rare Plants list that has been confirmed at the park is the white locoweed which occurs in mixed grass prairie. Bald eagles, least terns, and piping plovers are federally-listed species that occur in the vicinity of the park. The eagle occasionally roosts in the park, especially in the winter, while the other two species are primarily found on sandbars within the river channel. The federally-listed endangered pallid sturgeon is found in the Missouri River. Approximately 1.2 miles of river flow by the park (USGS National Hydrography Dataset). The river channel is now located some distance from the fort, in contrast to historic conditions when the two were in close proximity.

NATURAL RESOURCE GOALS AND OBJECTIVES:
The park is currently developing a Resource Stewardship Plan. The draft natural resource goals in the plan are:

- "The Missouri River is appreciated as a living entity, through its waters and habitats, as reflected in its on-going relationships to American Indian people. To fulfill this, the river would possess and maintain its natural hydrological and biological dynamic conditions in close proximity to Fort Union."

- "The landscape and viewsheds associated with Fort Union Trading Post are rehabilitated to represent the cultural features, ethnographic resources and natural environment depicted and documented by various historic records. A short-grass, warm season prairie, whose composition, form and function support native vertebrate species, is maintained through ecological and cultural processes. The rehabilitated prairie, from the park boundary in toward the palisades, represents a time period from just prior to post construction to the years midway through occupation.

- "Approaches to Fort Union Trading Post are open and elicit a remote feeling, with the landscape looking much as it did in an 1833 Bodmer painting of the area. A healthy stand of large cottonwoods are established on the south side of the river. There is a visual and physical connection to the river confluence. Views out from Fort Union Trading Post retain the primary characteristics of openness and remoteness.

NATURAL RESOURCE ISSUES:
Recreating the scene and conditions of the 1850s is an overriding priority for the park. Contributing to the protection of Missouri River resources, such as the federally-listed pallid sturgeon, is an important regional goal. Exotic plants are a significant issue at the park and one that will likely continue into the future (exotics are also common on private lands bordering the park). The history of cultivation, livestock grazing, and gravel mining has had serious impacts on park vegetation. Three of the park's 14 vegetation types, comprising over half the park's area, are only semi-natural (dominated by non-native species). Native vegetation occurs primarily in the forested riparian zone with only small amounts (<25 acres) of natural prairie in the uplands. The prairie restoration efforts, which began in 1993, have planted primarily native grasses with very few forbs or shrubs. Crested wheatgrass and smooth brome are significant exotics in the restored areas. Leafy spurge and Canada thistle also occur. Potential future exotics include purple loosestrife and tamarisk. The lack of grazing is of concern to management because of its ecological affects and from a cultural perspective (i.e., grazing was common during the historic period when the post was in operation). Changes in riparian vegetation are a concern to park management due to the altered Missouri River hydrograph. The park would like to see woody vegetation re-established on the south side of the river. Adding a shrub component to the restored sites would benefit grassland birds (Panjabi 2005).

The Ft. Peck dam upstream on the Missouri River continues to alter the natural river hydrograph. Regular flooding of the riparian area is critical to maintaining herpetofauna diversity (Smith et al. 2005). Riverbank erosion (a natural process) is a concern to management because it jeopardizes cultural resources. Bank erosion is currently occurring on the south side of the river because of the removal of trees. However, control actions such as bank reinforcement may impact aquatic resources such as the endangered pallid sturgeon. The reach of river that flows by the park is on the state 303(d) list and is impaired for flow alteration and thermal modifications. Herbicides applied within the park for exotic plant control are a concern to park management. External pesticides (possibly insecticides as well as herbicides), specifically those from aerial spraying of sugar beets, are a concern to management. The small size of the park will continue to limit management options and cause external stresses to park resources. Cattle trespass occasionally occurs. There are cultural events at the park that may affect natural resources, e.g., visitor trampling of vegetation. Park staff observe high levels of wildlife mortality on the main road due to vehicle collisions. Energy development occurs in the vicinity of the park, affecting the viewscape and potentially affecting air quality.

PARK-SPECIFIC MANDATES AND REQUESTS TO MONITOR NATURAL RESOURCES:
There are no specific mandates for the park to monitor natural resources. Neighbors would like the park to monitor (and control) exotics, including tamarisk. Erosion control actions may require monitoring of pallid sturgeon.

CURRENT MONITORING PROJECTS:
The only systematic monitoring being conducted at the park by the NPS is weather and well water monitoring conducted by park staff and vegetation monitoring conducted by the Fire Effects program. A small number of other non-systematic efforts are conducted by the park or other entities. A complete list of past and current monitoring and replicable research efforts in and near the park can be found in Appendix D.

ADDITIONAL INFORMATION:
Detailed information on the park can be found at http://www.nps.gov/fous/index.htm and other NPS web sites, and in a cultural history of the site by Barbour (2001).

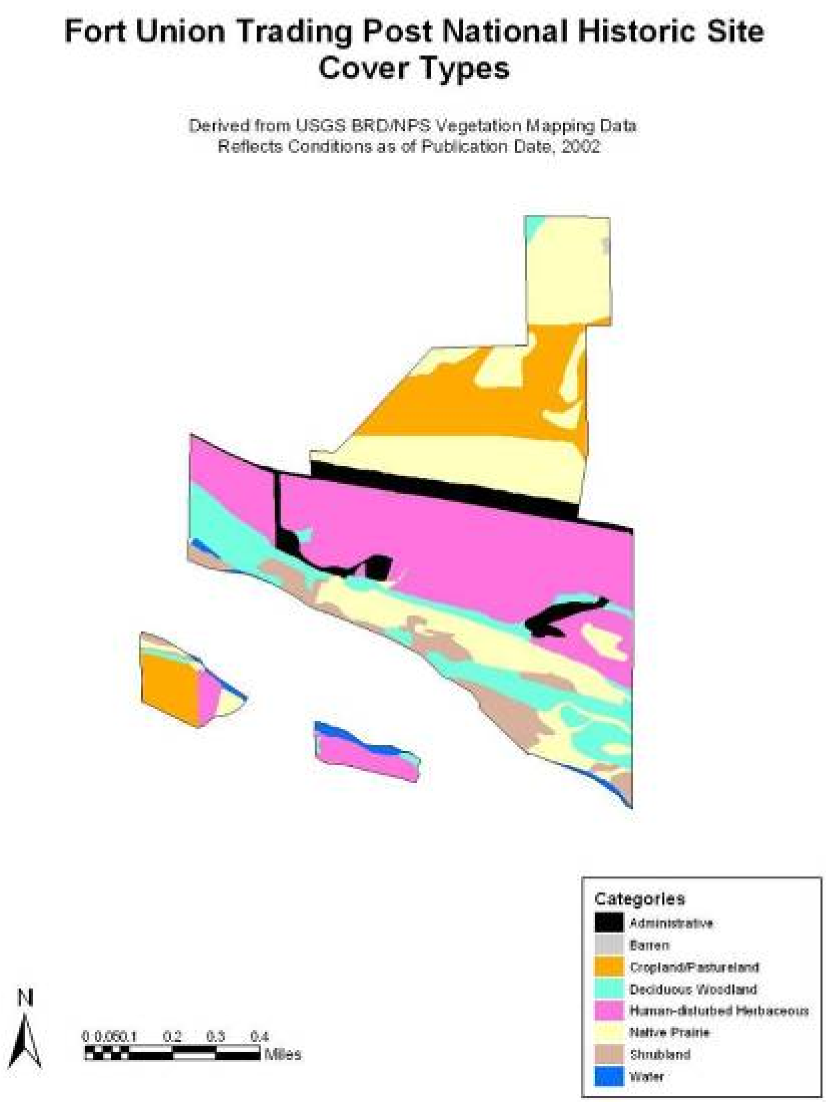

Figure 11. Fort Union Trading Post NHS Land Cover

Figure 12. Fort Union Trading Post NHS Monitoring and Research Sites

Jewel Cave National Monument

ENABLING LEGISLATION/HISTORICAL CONTEXT:
The entrance to Jewel Cave was discovered around 1900 by Frank and Albert Michaud when they noticed air blowing out of a small hole in the rimrock above Hell Canyon. They soon returned with tools to enlarge the entrance. The brothers made a mining claim on the site and developed and promoted it as a tourist attraction. Following the 1908 proclamation of the site as a national monument the brothers sold their claim to the federal government. Administration was transferred from the U.S. Forest Service to the NPS in 1933, and a boundary change occurred in 1965 to better protect the new cave routes that had been discovered in the interim. The enabling legislation recognized the scientific value and public interest in the cave as well as the need for adequately protecting the land surface above the cave. Cave tours at the historic entrance continued mostly uninterrupted until 1972 when the new visitor center was constructed with sealed cave entrances.

PARK MISSION:
The mission of Jewel Cave NM is to "preserve Jewel Cave, through management of the surface and subsurface ecosystem, while providing opportunities for the pursuit of scientific interests and public enjoyment." (from the park's 1999 GPRA goals).

GENERAL DESCRIPTION:
The 1,274-acre park lies in the southwestern Black Hills near the edge of the Limestone Plateau. The dominant vegetation is ponderosa pine interspersed with mixed-grass meadows. In August 2000, the 83,503-acre Jasper Fire burned through a large portion of the western Black Hills drastically changing the vegetation and appearance of the park. Guided cave tours are offered year round. There are two self-guided hiking trails within the park and other trails on the neighboring Black Hills National Forest. There is a small historic area that includes a CCC cabin built in 1935. All of the land surrounding the park is administered by the U.S. Forest Service. Hunting and trapping are not allowed, but do occur just outside the boundary.

DESCRIPTION OF NATURAL RESOURCES:
The cave is the primary natural resource at the park. Over 132 miles of passages have been surveyed, making it the third longest cave in the world. Airflow within the passages indicates a vast area yet to be explored. The cave is known for its wide variety of formations including speleothems, including stalactites, stalagmites, draperies, frostwork, flowstone, boxwork and hydromagnesite balloons. The known cave exists under about three square miles of surface area with 40% of it extending beyond park boundaries.

A 1996-97 land cover assessment found that 95% of the park was covered by forest, primarily ponderosa pine, making the park one of the least diverse parks in the Network in terms of land cover (Salas and Pucherelli 1998**b**: see Table 4). However, the Jasper Fire in 2000 burned a large portion of the forest and will likely result in an increase in open areas and herbaceous cover in the near future. The 1996-97 vegetation mapping identified 13 distinctive vegetation types. Only one of the types is considered globally vulnerable: the *Ponderosa Pine - Mountain Ninebark Forest* type. In addition to six types dominated by ponderosa pine, stands of boxelder, aspen, and chokecherry were found along drainage bottoms. *Western Snowberry Shrublands* were also present. How much of these remain following the fire is unknown. Herbaceous openings in the forest are dominated by western wheatgrass, little bluestem, side-oats grama, blue grama, and thread-leaf sedge. Despite the pervasiveness of ponderosa pine, there is some floral diversity due in part to microhabitats such as springs and seeps (Marriot 1985). The Jasper Fire appears to have had varying effects on park vegetation. Prescribed fires conducted in portions of the park prior to the Jasper Fire successfully reduced fuel loads so that the fire was cooler in these areas and tree mortality was relatively low. However, higher fuel loads in the majority of the park resulted in significant tree mortality. In general, ponderosa pine forest is now less extensive and the area of meadows with herbaceous vegetation has increased. The number of snags has increased greatly. Invasive plants, primarily Canada thistle, do occur at the park and other troublesome exotic plants seem to have increased since the Jasper Fire. Prior to this disturbance Marriot et al. (1999) considered the Jewel Cave area as a potentially exemplary site in their evaluation of Black Hills plant communities. The condition of all but one of the native vegetation types was ranked as “B”, the exception being *Ponderosa Pine - Common Snowberry Forest*, which ranked “AB”. Finally, there are some very small (<5 acres) areas of the park that may never have been logged and therefore are unusual in the Black Hills. For a more thorough discussion of plant resources at the park see Symstad (2004).

Of all of the wildlife species at the park, bats are the most studied and of most concern to management. Nine species of bats use the park at some point during the year. The cave is a hibernaculum for several species. In 2005 investigators found 493 individuals of the genus Myotis and 1,060 Townsend’s big-eared bats (two other individuals could not be positively identified). Townsend’s big-eared bats are noteworthy since the cave supports one of the largest hibernating colonies in the world and they are a species of concern in South Dakota. There is evidence that nursery sites for the species may occur in the vicinity of the park. All of these species also roost in the cave during warmer months. The diversity of species using the cave is due in part to the range of micro-climates within the cave. Hoary bats and silver-haired bats use the ponderosa pine trees in the park for daytime roosts, but do not regularly use the cave (they migrate south in the winter). Many pregnant Myotis can be found in nursery colonies in ponderosa pine snags, rock crevices, and buildings. Hoary bats, silver-haired bats, and big brown bats are also reproductively active within the park. Although bat use of the cave is likely of recent origin and the result of anthropogenic changes to the cave entrance, the site is recognized as having high regional biodiversity value and hence, is protected by park staff (see Tigner and Stukel 2003). Mountain lions are another species of high interest to visitors and park staff. Their sign is occasionally observed at the park (Schmidt et al. 2004). Bird richness and density likely changed dramatically immediately following the Jasper Fire. A 2002-04 study found extremely high densities of black-backed woodpeckers, a fire-associated species and a species of concern (Panjabi 2005). However, the most recent data suggests that woodpecker numbers may be decreasing while overall bird abundance may be recovering from the fire (Panjabi 2005). Herpetofauna richness could be as high as 11 species (Smith et al. 2005) and at least 53 butterfly species occur at the park (Marrone 2004*a*). Jewel Cave NM does not have any permanent fish habitat.

There are no federally-listed threatened or endangered plants or animals at the park. A 1986 vegetation survey (Marriott and Hartment 1986) listed four South Dakota rare plant species that are either suspected to be or are confirmed as in the park. Hopi tea and Hooker's Townsend-daisy are confirmed in the park (though Marriott and Hartment reported that Hopi tea may have been planted) and the habitat is suitable for sleepy grass and Easter daisy. The park's plant list also includes smallflower columbine, a U.S. Forest Service sensitive species. The Nature Conservancy's Black Hills ecoregional conservation plan (Hall *et al.*, 2002) states that the vicinity of the park is known to house muskroot, or moschatel, a secondary plant target. This species has not been documented in the park, however. Bald eagles are occasionally seen in the vicinity of the park and are the only federally-listed species know to use the site. Six of the bat species (fringed myotis, northern myotis, western small-footed myotis, long-eared myotis, silver-haired bat, and Townsend’s big-eared bat) are listed as species of concern by the South Dakota Natural Heritage Program. Black-backed woodpeckers are a species of concern that prefers the recently burned conifer forest. The tawny crescent butterfly is a species of concern which is also known to occur in the area.

Other than a wastewater treatment pond, there is no permanent surface water at the park. Surface water can be found in Hell Canyon and other drainages in the park during wetter periods. There are three springs in the park with moist soil and associated plants. One of these springs flows into a stock tank within the park.

NATURAL RESOURCE GOALS AND OBJECTIVES:

Management objectives for Jewel Cave NM (from the 1999 RMP) are:

- To monitor, maintain, restore, and protect the natural systems and conditions that exist in the Monument
- To plan and manage surface resources and developments in order to maintain, restore, and protect natural systems and conditions within the Monument
- To work with the Black Hills National Forest and neighboring landowners to ensure that land uses adjacent to the Monument do not threaten portions of the cave system that extend beyond park boundaries
- To identify, document, and protect significant plant and wildlife resources within the Monument

NATURAL RESOURCE ISSUES:
Protecting the integrity of the cave and the karst system as a whole is a priority for park management. Visitors transport foreign objects into the cave such as lint, hair, and skin cells and they sometimes touch and/or break cave features. Because more than 40% of the known cave is outside the park boundary the park is concerned about impacts to the integrity of the karst system from neighboring landowners. In addition, housing development may occur approximately 1 mile east of the park. Mapping the extent of the cave is a high priority for park staff.

Approximately 80-90% of the park burned in the Jasper Fire of 2000. Recovery of vegetation has occurred in some sites, but not others. Exotic plants will continue to be a management issue throughout the park. The effectiveness and indirect effects of control actions, such as the use of herbicides, is a concern for management. The use of prescribed fire will remain a management issue. The park would like to maintain some of the meadows. A gate is placed at the cave entrance used by bats. Feral cats have been observed taking bats at the entrance to the cave. There is a potential for microbial life in the cave so studies are needed. Modifications of springs with dams, boxes, and tanks has likely reduced herpetofauna (Smith et al. 2005) and Lepidoptera (Marrone 2004*a*) habitat.

Visitation issues such as transportation and infrastructure continue to be a management concern. Significant highway realignment and construction of a new bridge over Hell Canyon may occur. The sewage system is of concern to park management because of its affects on the environment and the potential for leaks and overflow. Air quality from current and proposed energy development in Wyoming is a concern. A proposed State of South Dakota cement quarry in lower Hell Canyon could affect air quality at the park.

PARK-SPECIFIC MANDATES AND REQUESTS TO MONITOR NATURAL RESOURCES:
There are no specific legislative mandates for natural resource monitoring at the park. The Black Hills National Forest has an ambitious bird monitoring program that they would like the park to contribute to.

CURRENT MONITORING PROJECTS:
Most of the long-term monitoring at Jewel Cave NM has focused on cave resources. The park has been collecting cave climate data since 1986, specifically temperature and humidity readings at 23 sites. Water quality has been collected in the cave since the early 1990s, as well as from several springs. Mid-winter bat surveys have been collected for many years. Christmas bird counts and breeding bird surveys have been conducted in recent years; however the counts have been irregular. Systematic GPS-mapping of exotic plants, specifically noxious weeds, has occurred in recent years. Several other short-term or non-systematic monitoring or research projects are being conducted. A complete list of past and current monitoring and replicable research efforts in and near the park can be found in Appendix D.

ADDITIONAL INFORMATION:
Detailed information on the park can be found at http://www.nps.gov/jeca/index.htm and other NPS web sites, in a popular account by Hucko (2002), and in the park's General Management Plan (National Park Service 1994*a*).

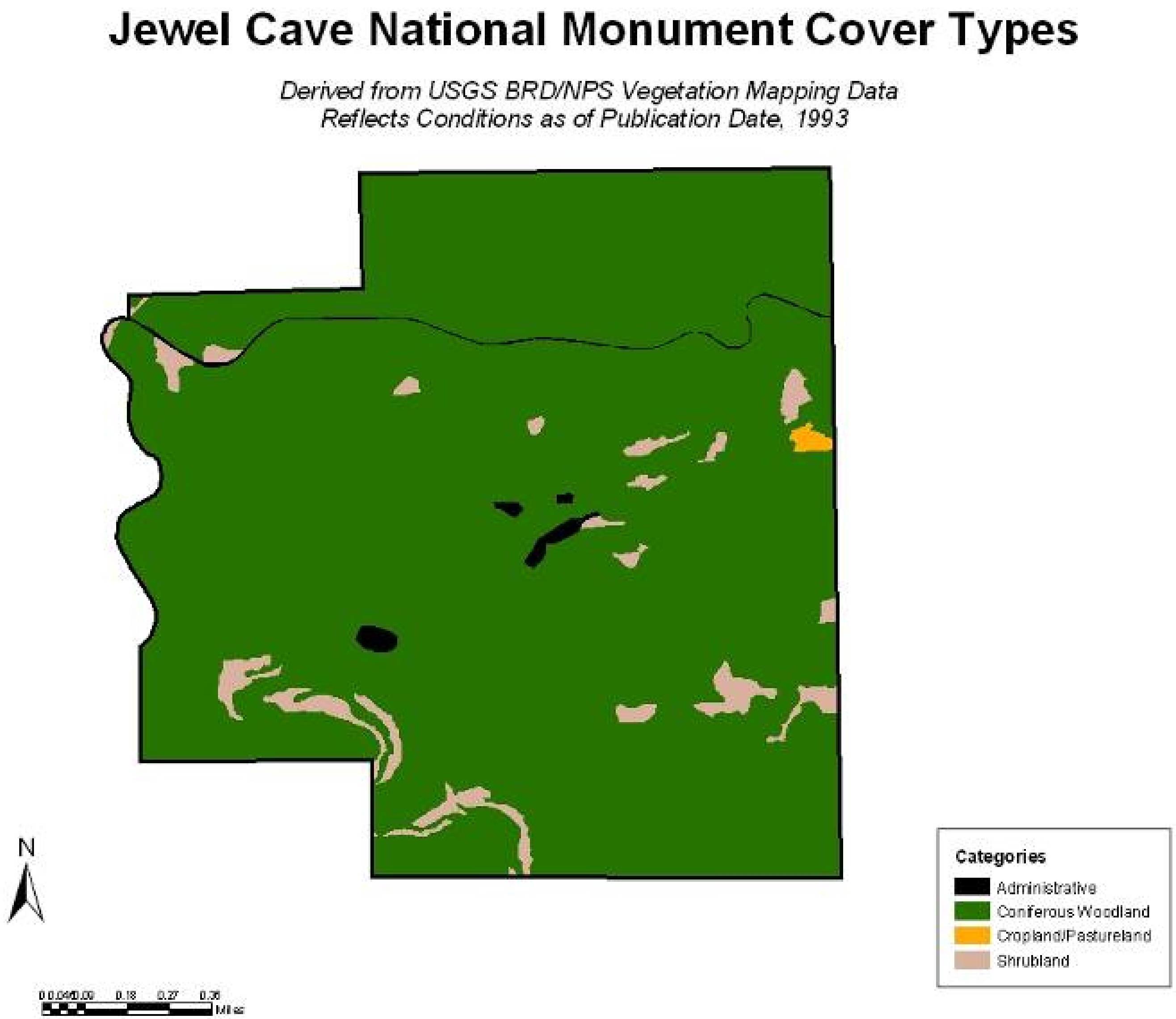

Figure 13. Jewel Cave NM Land Cover

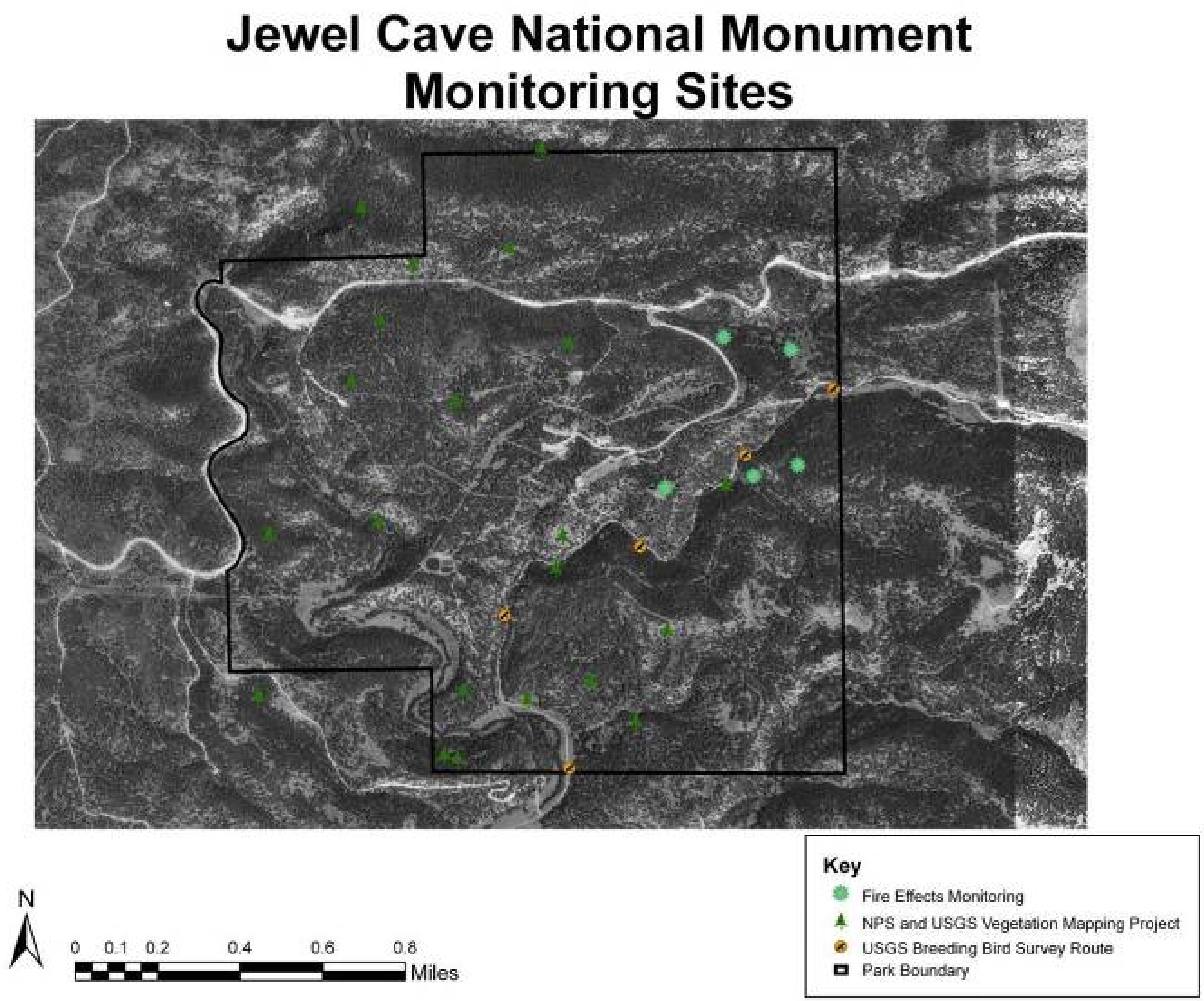

Figure 14. Jewel Cave NM Monitoring and Research Sites

Knife River Indian Villages National Historic Site

ENABLING LEGISLATION/HISTORICAL CONTEXT:
Knife River Indian Villages NHS was authorized in 1974 with a boundary change in 1990. The congressional reports supporting the enabling legislation stated that the park was intended to preserve historic and archeological remnants for the cultural and agricultural lifestyles of the plains Indians. The history of land use in the vicinity of the park begins 10,000 years ago with Native Americans who traversed the area while hunting and gathering. Hidatsa and Mandan tribes ultimately settled in the area, built earth lodges and lived an agrarian lifestyle. After the 1837 smallpox epidemic the Hidatsa and Mandan abandoned the villages at the site. During the latter half of the 19th Century steamboats frequented the area and created "wood yards" on the Missouri River bottomlands, with the largest of these occurring at the site of the park. Permanent European settlement occurred around 1882.

PARK MISSION:
To park's purpose is to "preserve, protect, and interpret the culture and agricultural lifestyles of the northern Great Plains Indian peoples and to conduct archeological research to further the understanding of the culture" (draft statement: J. Moeykens, pers. comm.).

GENERAL DESCRIPTION:
Knife River Indian Villages NHS lies in central North Dakota, on the west side of a free-flowing reach of the Missouri River. The park consists of 1,758 acres, with approximately 164 non-federal acres within the park boundary. The park encompasses the lower reach of the Knife River and its confluence with the Missouri. The village of Stanton (1990 pop. 345) is immediately south of the park. Most of the surrounding lands are used for agriculture. Hunting and trapping are not allowed at the park, but do occur just outside the boundary.

DESCRIPTION OF NATURAL RESOURCES:
Two physiographic zones exist within the park. The first of these is the low floodplain found immediately adjacent to the Knife and Missouri Rivers. Historically, this zone was inundated and scoured during spring runoff or large rain events. Today, the lower zone is covered by established woodlands known as the Missouri River bottomlands. The second physiographic zone is the "terrace" (i.e., the older and higher floodplain). This zone is typically separated from the lower floodplain by a distinct scarp or edge. The terrace zone is a mosaic of native mixed-grass prairie, old agricultural fields, and restored prairie.

The park's vegetation was mapped in 2002 according to NVCS standards, yielding 14 vegetation associations (Salas and Pucherelli, 2003*b*). In terms of land cover, the park is relatively diverse with 44% classified as human disturbed areas (e.g., old cultivated fields), 22% as forest, and 20% as native prairie. Only three of the vegetation associations are considered globally vulnerable or worse: *Northern Plains Transition Bluestem Prairie* is a western outlier of tallgrass prairie and occurs in the Big Hidatsa Pasture within the park; the *Green Ash - Elm Woody Draw* association is the most common woodland type in the park, but much of it is missing the shrub component; and the *Cottonwood - Green Ash Floodplain Forest* association probably existed to a greater extent historically, but flood control on the Missouri River and heavy smooth brome infestation in the understory has hindered tree regeneration. In addition to these vegetation types, four small areas were noted in two previous vegetation surveys for their diversity or uniqueness. Clambey (1985) and Lenz (1993) noted a small collection of low stabilized dunes just east of the Knife River where sandy soils produced vegetation different from the rest of the park. Lenz (1993) also noted: (1) a narrow woodland along the bottom of a low escarpment at the edge of the old river terrace where the trees were tall and well-formed (compared to stunted trees elsewhere in the park) and tree regeneration was occurring; (2) a very steep wooded bluff of the Missouri River which has some of the highest plant species richness in the park; and (3) at the bottom of this bluff a mixture of communities that may represent relatively undisturbed floodplain vegetation.

Another noteworthy feature of the park's vegetation is that one of the large cottonwoods is believed to be the 3rd largest in the state. For a more thorough discussion of plant resources see Symstad (2004).

White-tailed deer and ring-necked pheasant appear to be especially abundant. Other notable wildlife species include various owls and raptors, wild turkey, badger, coyote, beaver , sharp-tailed grouse, and waterfowl, among others. The forested area is especially noteworthy for its very high bird diversity (Panjabi 2005). As many as 14 species of herpetofauna may be present (Smith et al. 2005). Lepidoptera diversity is generally high; however, widespread burning has reduced habitats in some areas (Royer 2004). The river reaches within the park provide habitat for at least 26 species of mollusks and nine species of fish.

The park does not support any federally-listed threatened or endangered plant species, nor does it support any North Dakota-listed rare plants (Lenz, 1993). Bald eagles are common in the vicinity of the park. Although nesting is suspected, successful fledging of young has not been confirmed within park boundaries (active nesting does occur elsewhere in the Missouri River floodplain). Piping plovers and least terns both use sandbars in the Missouri River and may fly over the park. Some endangered pallid sturgeons may move a short ways up the Knife River. Water resources are significant to the park since both the Missouri and Knife Rivers flow by or in the park, totaling about 5.4 river miles in and abutting the park. Neither river has bank reinforcement so bank erosion can and does occur.

NATURAL RESOURCE GOALS AND OBJECTIVES:
The natural resource goals and objectives for the park are being developed as part of current planning processes.

NATURAL RESOURCE ISSUES:
Unfortunately, very few of the park's plant communities are in good condition. Three of the vegetation associations are characterized by invasive species (*Smooth Brome, Canada Thistle, and Crested Wheatgrass Semi-Natural Herbaceous Vegetation Types*) and four of the associations were planted with perennials—including some non-natives—when the park was established. Together, these degraded units comprise 42% of the vegetated area of the park. Generally speaking, smooth brome and crested wheatgrass are problems in the restored grasslands, smooth brome and leafy spurge occur extensively in floodplain woodlands, and absinth wormwood is scattered throughout. The success of the prairie restoration on the formerly cultivated lands is significant resource issue. The lack of grazing is also a concern to park staff; however, it is viewed as less of an issue than exotic plants and restoring the cultivated prairies. The health of the riparian forest is a concern because of the lack of cottonwood regeneration due primarily to cessation of Missouri River flood events due to upstream dams. The altered hydrograph likely has other impacts such as changes to rates of shoreline erosion. The park is concerned about the effects of deer herbivory on forest regeneration. Although hunting is allowed outside the park boundaries, many deer appear to seek refuge within the park boundaries. Forest health is also affected by heartrot fungus and Dutch elm disease (Lenz 1993). Management actions, including herbicide use in uplands and mechanical thinning in forested areas have reduced bird richness and abundance (Panjabi 2005). Spring burning may be deleterious to herpetofauna (Smith et al. 2005) and wide-spread burning in parts of the park have degraded habitat for butterflies (Royer 2004). Park staff are concerned that small mammals, such as ground squirrels, are contributing to the degradation of the archeological resources (e.g., burrowing exposes artifacts which makes them prone to theft).

Water quality, especially on the Knife River, is a concern. The upstream reach of the river flows through an agrarian landscape that experiences pesticide use, cultivation, and livestock operations. The river is currently listed as 303(d) and is impaired for pathogens. Numerous coal-fired powerplants are in the vicinity of the park, e.g., there are 11 plants within 25 miles of the park. New power plants are being built or proposed within the region. Air quality monitoring in the vicinity of the park is considered inadequate (Pohlman 2005).

PARK-SPECIFIC MANDATES AND REQUESTS TO MONITOR NATURAL RESOURCES:
There are no known park-specific mandates for monitoring.

CURRENT MONITORING PROJECTS:
The NPS Fire Effects program has systematic monitoring plots established at the park. Less systematic vegetation monitoring, including the use of photo points, is conducted by the EPMT and park staff. Non-systematic monitoring is conducted of heart rot in the riparian forest. A USGS flow gauge is located in the Knife River. A complete list of past and current monitoring and replicable research efforts in and near the park can be found in Appendix D.

ADDITIONAL INFORMATION:
Detailed information on the park can be found at http://www.nps.gov/knri/index.htm and other NPS web sites, and in the park's General Management Plan (National Park Service 1986).

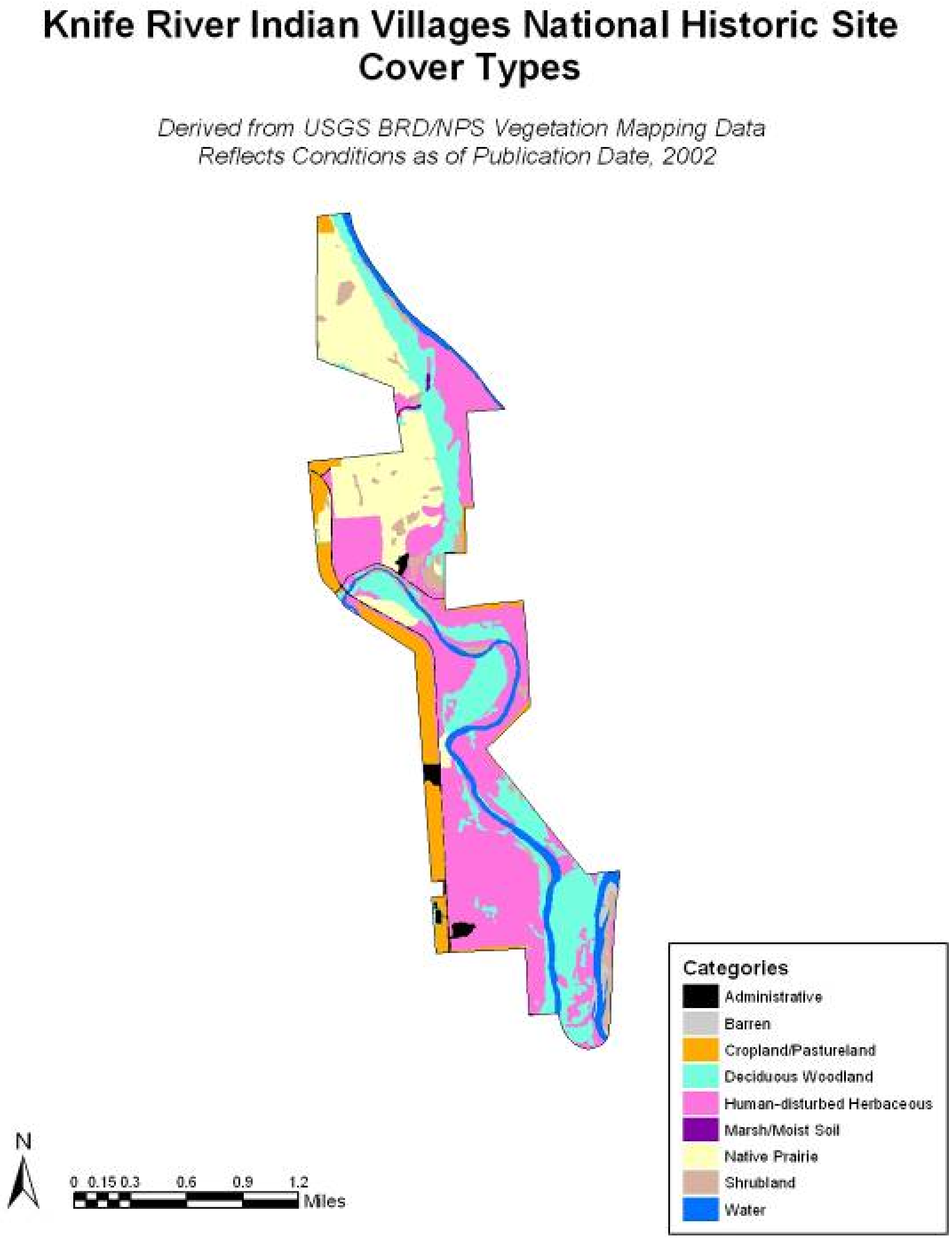

Figure 15. Knife River Indian Villages NHS Land Cover

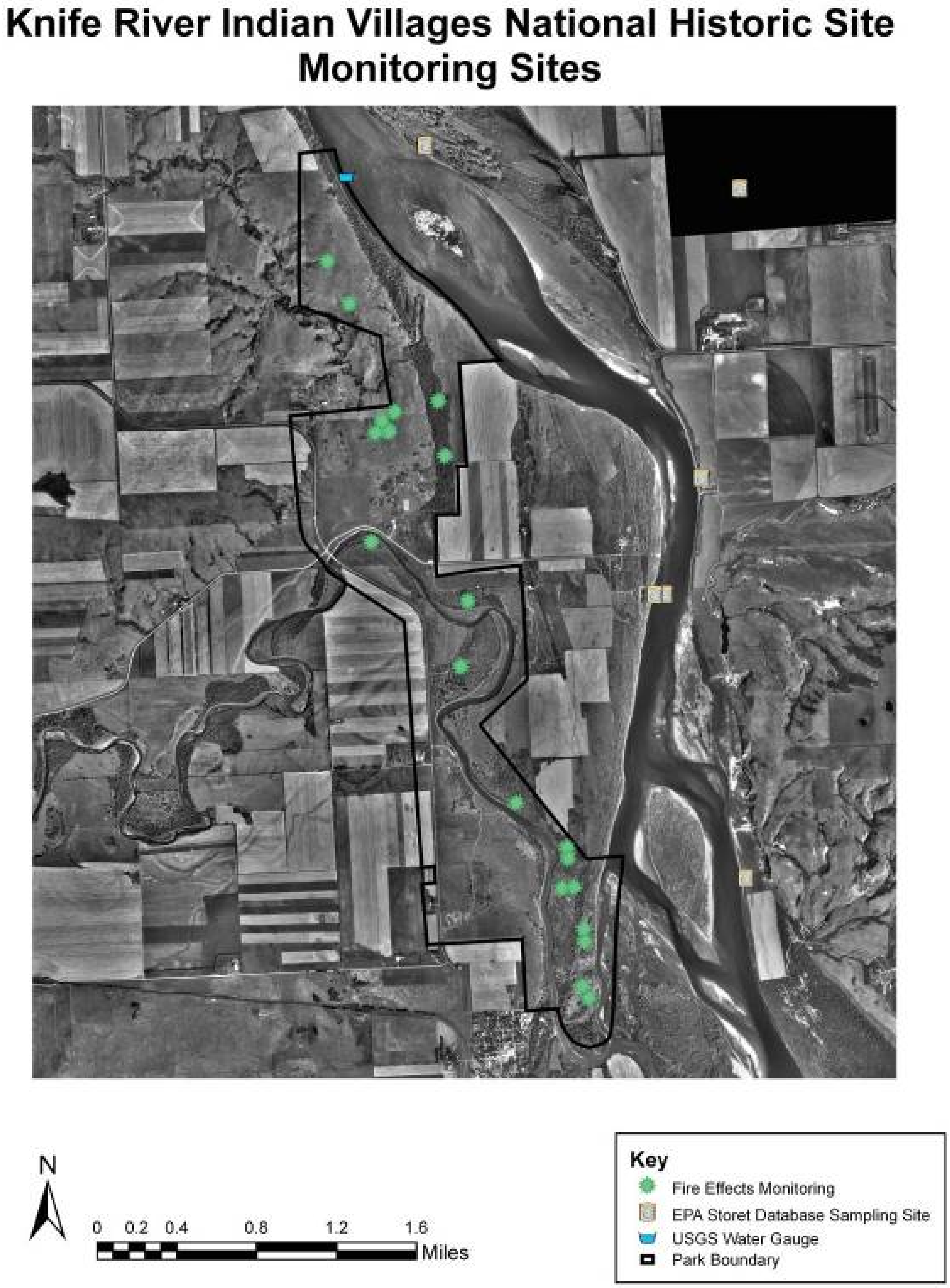

Figure 16. Knife River Indian Villages NHS Monitoring and Research Sites

Missouri National Recreational River

ENABLING LEGISLATION/HISTORICAL CONTEXT:
The Missouri National Recreational River was authorized in 1978 with establishment of a 59-mile eastern segment and expanded in 1991 with establishment of a 39-mile western segment. These areas were designated under the Wild and Scenic Rivers Act to preserve the free-flowing nature of the river and the wildlife dependent upon it.

PARK MISSION:
There is no park-specific mission statement.

GENERAL DESCRIPTION:
The park boundary encompasses 69,123 acres, primarily consisting of two sections: a 59-mile eastern reach (a.k.a., 59-mile District) and a 39-mile western reach (a.k.a., 39-mile District). The eastern reach stretches from Gavins Point Dam near Yankton, South Dakota (pop. 13,528) to near Ponca, Nebraska (pop. 1,062). The western reach, also known as the upper reach, occurs between Lewis and Clark Lake and Fort Randall Dam. This section includes 20 miles of the lower Niobrara River and 8 miles of Verdigre Creek in Nebraska. The Yankton Indian Reservation lies along the north boundary of the upper portion of the reach. The park is unconventional in that most of the property within the boundary is comprised of non-NPS holdings. Current NPS holdings consist of a 100-acre Bow Creek site that contains bottomland and oxbow habitat and a 30-acre Mulberry Bend Overlook site for interpretive purposes. Other small acquisitions may occur in the future such as the 60-acre Goat Island in the Missouri River (currently administered by BLM). The forested island was present at the time of Lewis and Clark. The park achieves its goals by coordinating and collaborating with federal, state, tribal, and local jurisdictions and private landowners. Significant natural areas within the park administered by other agencies are Niobrara, Ponca, Randall Creek, and Spirit Mounds State Parks, Corps of Engineers properties, and the Karl Mundt National Wildlife Refuge. Hunting, fishing, and trapping are allowed.

DESCRIPTION OF NATURAL RESOURCES:
Approximately 45% of the surface area within the park boundary is comprised of water, primarily the Missouri River (National Land Cover Dataset 1992: see Table 4: the park has not been mapped by the USGS/NPS vegetation mapping program). A significant percentage of human disturbed land cover (20%), primarily cropland, also occurs within the park boundary. The vegetation of the park is dominated by central plains riparian forest. However, numerous other vegetation types occur including native and restored tallgrass prairie, oak woodlands, pastures, plowed fields, and residential areas. Because the park encompasses numerous ownerships the condition of the vegetation varies considerably from site to site. For example, in Ponca State Park native vegetation dominates whereas outside of protected areas much of the native vegetation has been impacted by agriculture, grazing, and residential development. Invasive species such as Russian olive and purple loosestrife are problematic. For a more thorough discussion of plant resources at the park see Symstad (2004). Wildlife is typical of an agrarian area landscape. Extirpated species include bison, elk, bears, and wolves. Mountain lions are occasionally reported but are almost certainly non-resident. Anthropogenic impacts have resulted in the recent occurrence of some species not native to the site such as oppossums.

The park contains more federally-listed endangered and threatened species than any other park in the Network. The management of these species is contentious and complex. For example, the shifting sandbars in the river provide nesting habitat for the threatened Great Plains population of the piping plover and endangered interior least tern. However, the presence and operations of the dams directly affects the creation of the sandbar habitat needed by the birds. The river also supports the endangered pallid sturgeon. Wetlands and backwater chutes are especially important to the species because they provide warm calm waters preferred by the sturgeon. Although comparatively less contentious, the bald eagle can be found throughout the park and in all seasons. In 2004 14 active nests were documented in the park. Significant winter roosts occur immediately downstream of the dams. Karl Mundt Refuge in the upper reach of the park is especially noteworthy for the presence of bald eagles. Topeka shiners may be in the park, but are not documented as currently being there. Whooping cranes could potentially occur during migration. Ospreys are a state listed species that have been reintroduced to the park. Less than one-third of the Missouri is undammed and unchannelized; therefore, these sections of river within the park are considered some of the best remaining examples of the river in its natural state. Features of the historic and dynamic river can still be found in the form of sandbars, islands, chutes, and snags. Bank erosion does occur at some sites, especially where trees have been removed and cultivation has occurred, however, rip-rap is common.

NATURAL RESOURCE GOALS AND OBJECTIVES:
The parks resource goals are to “emphasize management that conserves, protects, restores, and enhances riverine and terrestrial biological diversity, natural riverine processes and natural character” (W. Werkmeister, pers. comm.).

NATURAL RESOURCE ISSUES:
The unnatural flow regime in the Missouri River continues to be the most significant natural resource issue to the park. The altered hydrograph and dams have numerous negative effects on natural conditions and processes. For example, the dams block sediment transport in the river and the attenuated hydrograph reduces scouring events, with the result being a lack sandbar habitat. Similarly, snags are not as common in the river as they use to be. Likewise, the loss of periodic inundation of the bottomlands may be affecting cottonwood regeneration and nutrient cycling. Bank erosion continues to be a concern as does the methods used to prevent it. The degradation and reduction in backwater and oxbow habitats may be affecting amphibians and other wildlife. Missouri River management is primarily under the authority of the U.S. Army Corps of Engineers, with other government entities having various roles, confounding park management actions and direction.

Exotic plants are a concern to park staff and is water pollution from agricultural pesticides. The park has acquired a 100-acre floodplain area and hopes to acquire more sites in the future. The park would like to monitor the ecological conditions of these sites. Potential tools used at the sites include various exotic plant control methods and prescribed fire. The park works closely with state and private entities to conserve resources on those lands. There are many questions about the health of the protected areas within the park. For example, are the restored prairies at Ponca and Spirit Mound State Parks approaching natural conditions? State agencies would like the park to assist with monitoring the resources on their lands. The park anticipates establishing conservation easements. These sites will need to be monitored for compliance. Air quality monitoring in the vicinity of the park is poor (Pohlman 2005). A continuing challenge for the natural resource staff at the park is to determine how the park can be most effective with the myriad of other agencies and entities that have responsibilities, missions, and interests on the river. Park staff also struggle with understanding the complexities of the numerous entities, projects, and issues of the river.

PARK-SPECIFIC MANDATES AND REQUESTS TO MONITOR NATURAL RESOURCES:
There are no park-specific mandates to monitor natural resources.

CURRENT MONITORING PROJECTS:
Very little systematic monitoring is conducted by the park. The park does monitor zebra mussel presence and has coordinated and established a multi-partner zebra mussel working group which focuses on monitoring and awareness. The park participated in bald eagle recruitment monitoring in 2004 and will coordinate the multi-partner effort in 2005. The EPMT maps exotic plants on the lower Niobrara River and the Bow Creek property. Park staff document and treat exotic plants on NPS holdings. Nesting least terns and piping plovers are monitored on the Niobrara by the park while the Corp monitors populations on the Missouri River as required by Section 7 (ESA) consultation. The Corp regularly acquires remote imagery of the park in part for monitoring sandbar habitat, conducts water quality monitoring associated with dam operations, and conducts other monitoring projects. South Dakota Department of Game, Fish and Parks, U.S. Fish and Wildlife Service, and the Corp collaboratively monitor pallid sturgeon. The states of South Dakota and Nebraska monitor sport fish abundance. The Missouri Natural Resource Committee, a multi-state organization, oversees various monitoring projects on the Missouri River. The U. of South Dakota started a water quality monitoring program on the river, but long-term funding is uncertain. The USGS is working on a three year geomorphic assessment to assist the park in monitoring riverine fluctuations.

ADDITIONAL INFORMATION:
Detailed information on the park can be found at http://www.nps.gov/mnrr/index.htm and other NPS web sites, and in the General Management Plan (National Park Service 1999). Information on Missouri River resources and management can be found in the Missouri River Master Manual (U.S. Army Corp of Engineers 2004).

Figure 17. Missouri NRR Location Map

Mount Rushmore National Memorial

ENABLING LEGISLATION/HISTORICAL CONTEXT:
In 1925 legislation was passed to authorize the carving of the southeastern face of Mount Rushmore as, "a memorial … commemorative of our national history and progress" under the authority of the Mount Rushmore National Memorial Commission. In 1939 management of the site was transferred to the National Park Service. Boundary changes occurred in 1940 and 1949.

PARK MISSION:
No current mission statement is available.

GENERAL DESCRIPTION:
The 1,278-acre Mount Rushmore NMEM is located in the central Black Hills in southwestern South Dakota (40 acres are non-federal). The park is the most heavily visited unit in the Network. However, almost all visitation is for purposes of seeing the carved mountain and associated visitor facilities. A very small amount of rock climbing, nature observation, and hiking occurs in the park. Some horse riding occurs on the Blackberry Trail which connects to a larger trail system within the surrounding Black Hills National Forest. Hunting and trapping are not allowed at the park, but do occur outside the boundary. Fishing does not occur in the park due to a lack of fishable waters. Most of the land surrounding the park is administered by the Black Hills National Forest. The Black Elk Wilderness lies immediately south of the park. The town of Keystone (pop. 311) is located on the east boundary of the park. The town is almost entirely tourism dependent with the highest visitation in the summer.

DESCRIPTION OF NATURAL RESOURCES:
The land cover of Mt. Rushmore NMEM is 86% forest, primarily ponderosa pine, making the park relatively poor in terms of land cover diversity (Salas and Pucherelli, 1998*c*: see Table 4). However, the park is topographically diverse with steep canyons, cliff faces, and rocky outcroppings. There are three drainages in the park; Lafferty Gulch in the north central area, Starling Basin along the western and southern edges, and Grizzly Creek along the eastern side. These drainages contribute greatly to the diversity of the park, especially in regards to flora richness.

The dominant vegetation of the park is ponderosa pine, although aspen, paper birch, bur oak, and white spruce occur as well. The park vegetation was mapped according to NVCS standards in 1996-1997 (Salas and Pucherelli, 1998c). Eight vegetation types were described for the park, two of which are globally vulnerable or worse: they are *Paper Birch / Beaked Hazel Forest* and *Ponderosa Pine / Bur Oak Woodland*. The vulnerability of several other types is not certain because their global extent is unknown (see Symstad 2004). The Nature Conservancy's Black Hills Community Inventory (Marriot et al., 1999) considered all but one of the vegetation types in the park to be in grade "B" condition, the exception being the *Ponderosa Pine / Bearberry Woodland* type which was given a grade of "AB." This generally good condition is reflected in the relatively low amount of invasive species, especially in the non-disturbed sites. Most of the park appears to have been logged prior to its establishment, but perhaps 25% of the park, including portions of the Starling Basin and the Lafferty Gulch area, may be classified as old growth ponderosa pine (Symstad in prep.). One stand of old-growth ponderosa pine in the Starling Basin was estimated to be over 200 years old (Hoffman and Hansen 1986) and Symstad (in prep) has documented trees over 400 years old. Since much of the surrounding Black Hills National Forest has been logged, the old growth at the park is a unique and valuable resource. Recent thinning operations elsewhere in the park have reduced the density of young pine stands. The long period of fire suppression in the area has undoubtedly affected the diversity and composition of the vegetation. For a more thorough discussion of plant resources at the park see Symstad (2004).

Panjabi (2005) reported that the granite outcrops of Mt. Rushmore provide habitat for white-throated swifts, canyon wrens, and violet-green swallows. He also stated that the old growth forest provides quality habitat for brown creepers, goshawks, and black-backed woodpeckers. The Starling Basin wetland complex is considered an important site in the Black Hills for herpetofauna (Smith et al. 2005) and butterflies (Marrone 2004*b*). The entire park provides good habitat for bats (Schmidt et al. 2004). A 2001 fish inventory found only longnose dace and brook trout in the park, with the latter being more abundant (White et al. 2002). Brook trout are an introduced species in the Black Hills. A small population of introduced mountain goats move in and out of the park. Mt. Rushmore NMEM does not have any resident federally listed threatened or endangered species, although bald eagles are occasionally observed in the area. It is not certain to what extent the park harbors plants on the South Dakota rare species list. Mountain lions or their sign are regularly observed in the park; they are on the state species of concern list.

NATURAL RESOURCE GOALS AND OBJECTIVES:
The park does not currently have explicit resource goals or desired future conditions.

NATURAL RESOURCE ISSUES:
Exotic plants are a significant concern to park staff. Although not as pervasive a problem as at other parks (especially those with a history of cultivation), exotic plants are present including noxious ones such as Canada thistle and leafy spurge. Disturbed areas such as roadsides and around developed areas have significant levels of both of those as well as annual brome grasses, houndstongue, mullien, and spotted knapweed. There are about 100 acres of land at the park that were disturbed as the result of development activities. These acres are in need of native plant restoration. The non-native mountain goats are an issue to park staff because their presence conflicts with NPS management policies, and to a lesser extent because they may be having deleterious impacts to park vegetation and can be a safety issue to visitors and vehicle traffic. Fire management is a high priority to park staff. Parts of the park, and some of the adjoining properties, consist of dense highly flammable stands of pole-size ponderosa pine. Mechanical thinning (under the direction of the FirePro office at Wind Cave NP) is being conducted at some of these areas. The natural fire regime has been greatly impacted by decades of suppression. The park would like to conduct prescribed burns, but current conditions makes that risky and challenging.

Protecting the integrity of the Starling Basin (i.e., the wetland and the old growth ponderosa pine) is a priority for park staff. Its ecological significance has been noted by numerous ecologists (Schmidt et al. 2004, Panjabi 2005, Smith et al. 2005). Park staff also have interest in the Black Elk Wilderness being expanded to include the basin and the old growth areas within the park. The pine beetle, although native to the Black Hills, is often viewed as a serious pest. The species can quickly kill entire stands of pines, especially very dense stands such as those that develop in the decade or two following clearcuts. Trees stressed for other reasons (e.g., drought) are also susceptible.

Both water quality and quantity are an issue at the park, primarily as a result of the high numbers of visitors and the associated infrastructure. Surface water runoff from the parking lot and elsewhere is a concern. The park's waste system is approaching capacity, but a new treatment system is in the planning stages. The fresh water supply needed for visitors may also be approaching capacity. Climbers may have some impacts to park resources. There is some potential and evidence of falcon (especially prairie falcons) nesting in the park, but current visitation patterns may preclude that (Panjabi 2005). Air quality is a concern to park staff in large part because it could affect visibility of the monument. Western energy development may degrade views and air quality in the region. Aerial flights of tourists affect the soundscape and may have some impacts to wildlife resources (e.g., falcon nesting). Development continues in the vicinity of the park, especially at the town of Keystone near the east entrance to the park.

PARK-SPECIFIC MANDATES AND REQUESTS TO MONITOR NATURAL RESOURCES:
The enabling legislation refers to the forest setting and visibility, but there are no specific directives for monitoring. The state requires the park to monitor water quality in regards to the wastewater treatment facilities. The Forest Service would like the park to monitor forest fuels. The Black Hills National Forest has an ambitious bird monitoring program in the Black Hills which they would like to see the park contribute to.

CURRENT MONITORING PROJECTS:
The park funds a very sophisticated monitoring of the granite outcropping the monument is carved from, specifically to assure there's no significant expansion or movement from freezing and thawing and other processes. The NGP Fire Effects program has some monitoring plots established in the park and the EPMT program non-systematically monitors exotic plant distribution and abundance. The parks has a RAWS station.

ADDITIONAL INFORMATION:
Detailed information on the park can be found at http://www.nps.gov/moru/index.htm and other NPS web sites, in a cultural history of the site by Taliaferro (2002) and in a natural history of the Black Hills by Raventon (1994).

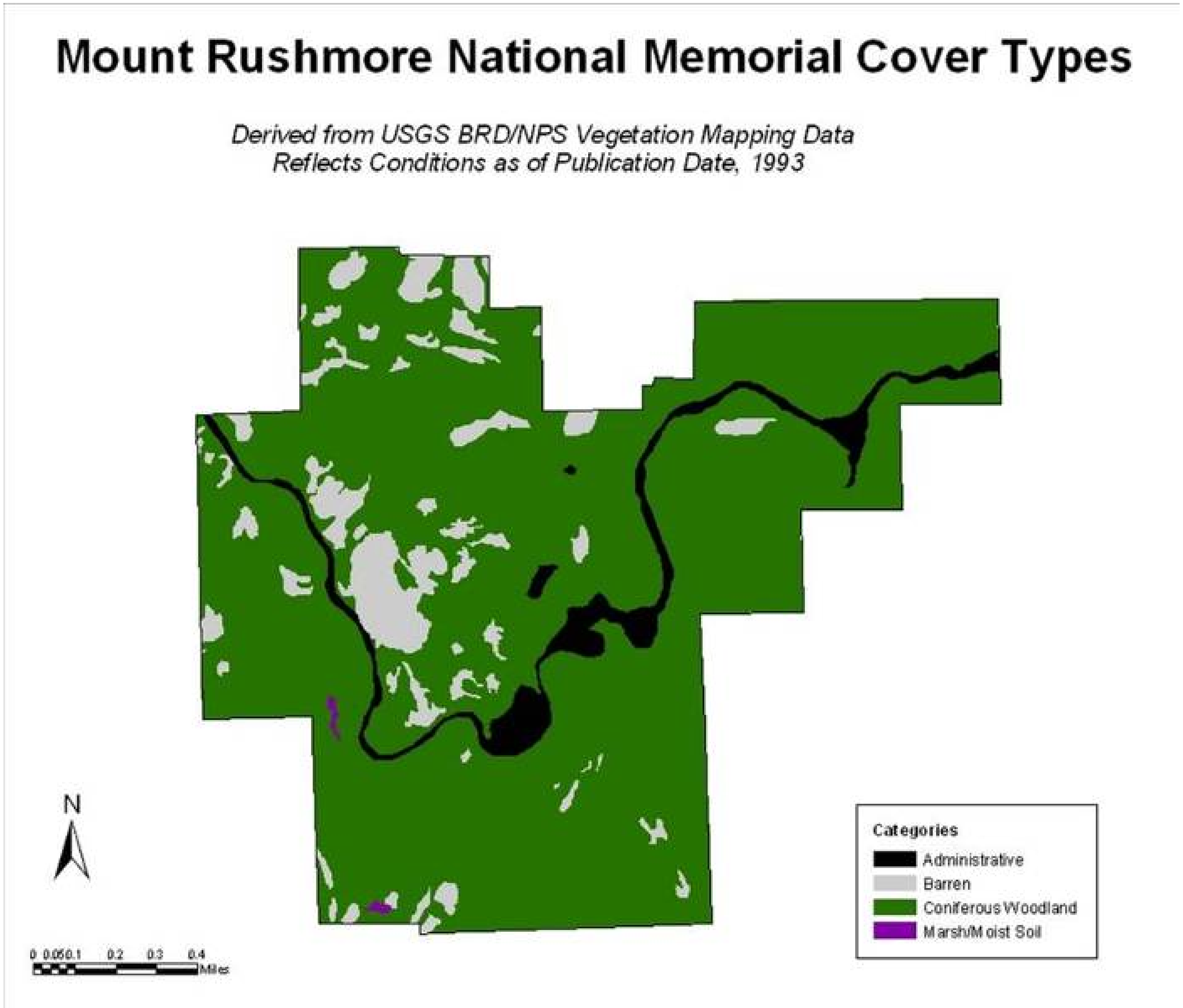

Figure 18. Mount Rushmore NMEM Land Cover

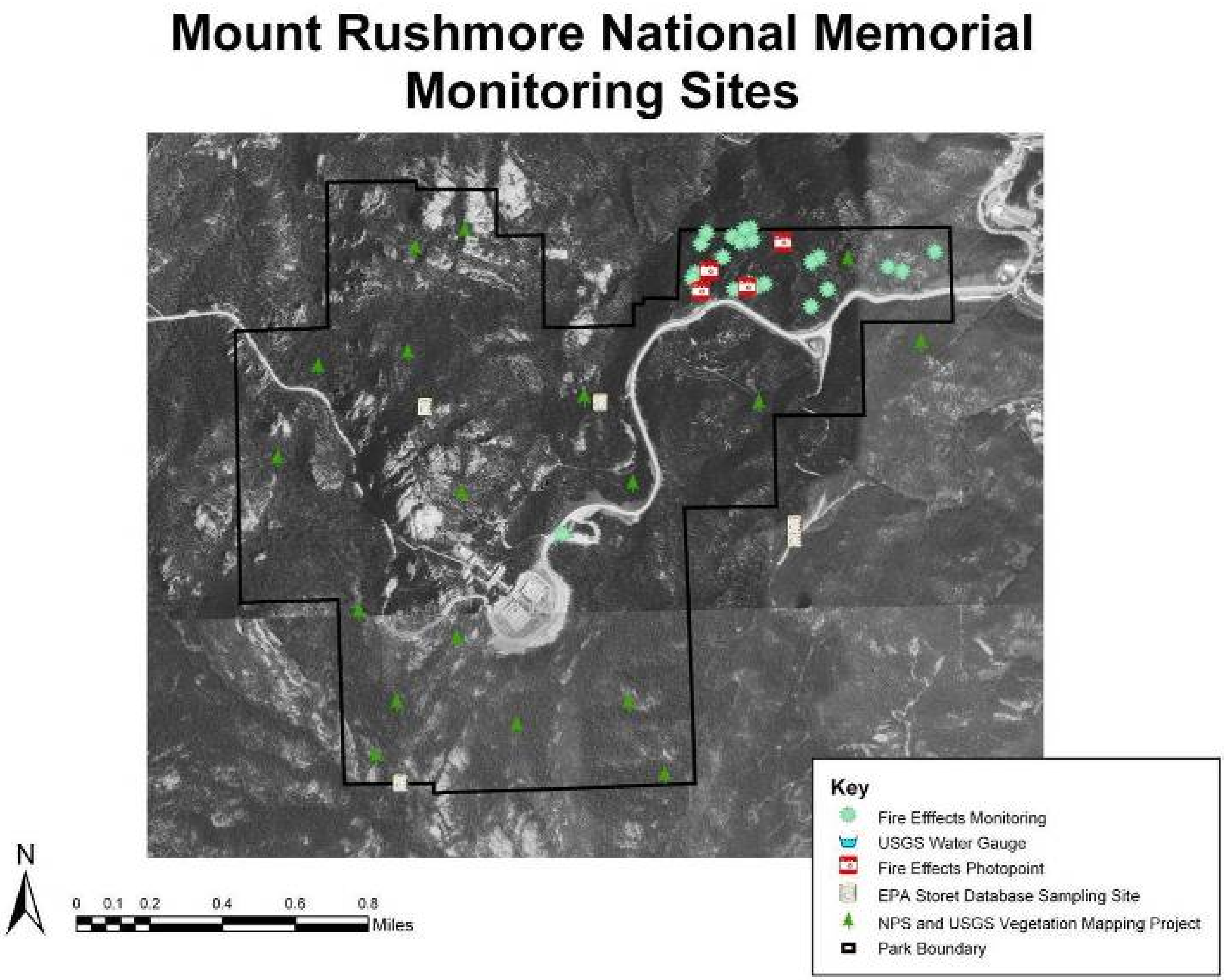

Figure 19. Mount Rushmore NMEM Monitoring and Research Sites

Niobrara National Scenic River

ENABLING LEGISLATION/HISTORICAL CONTEXT:
The Niobrara National Scenic River was authorized in 1991 and was added to the nation's Wild and Scenic River System in the same year.

PARK MISSION:
The mission of the Niobrara NSR is to preserve the river in its free-flowing condition; preserve the river's outstandingly remarkable values; work cooperatively with landowners, agencies, and others to respectfully manage the private and public lands of the scenic river; and to safely provide for a variety of recreational and educational opportunities and public access that does not adversely impact the river's resources (from the park's FY05-08 strategic plan).

GENERAL DESCRIPTION:
The 76-mile long park is located in rural north-central Nebraska. The park boundary encompasses 29,056 acres, however, only 790 acres are federally owned (those are administered by the U.S. Fish and Wildlife Service). Small parcels may be acquired in the future to accommodate visitors and/or for resource protection. Most of the land within the park is owned by private landowners or The Nature Conservancy. A portion of the park is in the Fort Niobrara National Wildlife Refuge (NWR). The park achieves its goals by coordinating and collaborating with federal, state, and local jurisdictions and private landowners. The park is enjoyed by tens of thousands of canoeists annually. The upper reach of the Niobrara is noted as one of the country's outstanding canoeing rivers. A portion of the river flows through a federally designated wilderness. The town of Valentine (pop. 2,820) is just upriver of the park and has an active tourism industry. Hunting, fishing, and trapping all occur within the park boundary although access is often limited by landowners.

DESCRIPTION OF NATURAL RESOURCES:
Approximately 41% of the land cover within the park boundary is classified as native prairie and 26% is forested (National Land Cover Dataset 1992: see Table 4). The percentage of forest may have increased from pre-European times due to fire suppression. About 20% of the surface area consists of water, primarily the Niobrara River. The park vegetation has not been mapped by the NPS/USGS vegetation mapping program, but Kantak (1995) described the plant communities of the area and outlined the general position of the communities with respect to the river. The park is widely known for being at an ecological crossroads where six distinct ecosystems and their associated flora and fauna mix. The ecosystems are northern boreal forest, eastern woodland, and Rocky Mountain forest types, tallgrass prairie, Sandhills prairie, and mixed-grass prairie. Many species, particularly those associated with the forests, reach their western, southern, or eastern limits along this stretch of the Niobrara River. Hybridization of species is common at the park. The condition of the vegetation varies depending on the particular property, so generalizations about the health of the vegetation are difficult to make. Invasive species, such as purple loosestrife are problematic as is encroachment of eastern red cedar into prairie. For a more thorough discussion of plant resources at the park see Symstad (2004). White-tailed deer, coyote, beaver, and other animals are commonly sighted. A lone moose was been recently documented within the park; it's unclear where the animal originated from since the nearest established population is well over a hundred miles away. The presence of otters is noteworthy because of their rarity in the state. Rare butterflies are also present in the park.

Federally-listed endangered and threatened species are found in the park. The Fort Niobrara NWR and The Nature Conservancy's Niobrara Valley Preserve, portions of which lie within park's boundaries, have potential habitat for two federally-listed threatened plant species; the western prairie fringed orchid and Ute lady's tresses. However, neither of these have been confirmed in the park per se. Twenty-eight plant species on the Nebraska Plants of Concern list (http://www.natureserve.org/nhp/us/ne/plants.html) have been found on the preserve, but which ones fall within the park per se is not clear. In terms of animals the federally-listed interior populations of the least tern and piping plover breed in the lower reaches of the Niobrara. Critical habitat for the piping plover was designated within a portion of the park in 2002. The bald eagle is fairly common and may nest within the park. Whooping cranes stop at the park during spring migrations. The river otter is a state-listed species known to occur in the park.

The river is a primary natural resource in the park. Geomorphic processes associated with the river are significant and comparatively rapid. The river is swift and shallow over much of its length, cutting through bedrock and forming riffles, rapids and waterfalls. Sandbars and snags are common on the river, especially the lower reaches. The spring branch canyons and tributaries are significant as is the two-hundred plus waterfalls that occur in the western third of the park. The highest is Smith Falls which cascades about seventy feet from a Sand Hills cliff.

NATURAL RESOURCE GOALS AND OBJECTIVES:
The park has no formal long-term natural resource goals and objectives or desired future conditions.

NATURAL RESOURCE ISSUES:
Management issues in the park focus primarily on the riverine system and aquatic resources. The loss of a natural hydrograph due to an upstream dam is a major concern to park staff. The altered hydrograph affects cottonwood regeneration, geomorphic processes, backwater habitats, and erosion rates. Complicating the issue is the fact that a USGS flow station on the river may be discontinued in the future. Continued operation of the gauge is a high priority to park staff. An increase in center-pivot irrigation in the uplands may affect local hydrology. Non-point pollution from cattle is a current concern and point pollution may occur in the future as more feedlots are established. Plum Creek and Long Pine Creek are listed as 303(d) impaired waters for pathogens and Minnechaduza Creek is listed for thermal modifications and pathogens. Some water pollution may occur as a result of the high number of canoeist and other recreationists on the river, with visitor use expected to increase in the future.

Flora and fauna issues are also tied to hydrologic issues. The park is concerned about birch regeneration in the steep tributary drainages being impacted by hydrologic and climate changes. The status of the federally-listed interior least tern, piping plover, and whooping crane—all species that use the river—is of concern to park management. Other wildlife populations of concern to park staff include invertebrates and herpetofauna. Park staff would like to conduct prescribed burns within the park. Doing so would require working closely with current landowners. Recreational development in the form of cabins and second homes will likely continue to increase, affecting visitor experience and park resources, as well as complicating management actions and objectives. Air quality monitoring in the park is considered poor compared to other Network parks (Pohlman 2005).

PARK-SPECIFIC MANDATES AND REQUESTS TO MONITOR NATURAL RESOURCES:
The Wild and Scenic River Act commits the park to insure water quality, which implies some level of monitoring. The state would like the park to monitor birch and aspen within the park boundaries and The Nature Conservancy would like monitoring of the waterfalls and spring branch canyons. The Fire Learning Network would like fire monitoring within the park.

CURRENT MONITORING PROJECTS:
Park staff annually monitor breeding populations and recruitment of least terns and piping plovers on the river. They also take twice-weekly water quality measurements from the river throughout the year, as well as from several tributaries in the summer. The Nebraska Department of Environmental Quality monitors water quality in the river on a 5-year cycle. The Nature Conservancy conducts systematic vegetation monitoring on their property within and outside the park boundary. The park annually takes photographs of developments within the park boundary. Park staff collect data from a weather station located on The Nature Conservancy property. Several research projects are being conducted in the park that have potential for replication for purposes of monitoring.

ADDITIONAL INFORMATION:
Detailed information on the park can be found at http://www.nps.gov/niob/index.htm and other NPS web sites, and in the draft General Management Plan (National Park Service 2005).

Figure 20. Niobrara NSR Location Map

Scotts Bluff National Monument

ENABLING LEGISLATION/HISTORICAL CONTEXT:
The 1919 Presidential proclamation establishing Scotts Bluff National Monument identified the site as a significant landmark to immigrants and frontiersmen traveling the Overland Trail on their journey to the west. The enabling legislation also recognized the unique geology of the bluff and surrounding terrain. Boundary changes occurred in 1924, 1932, 1940, and 1961.

PARK MISSION:
The park mission as established in the GMP is to: preserve Scotts Bluff, a prominent feature on the western Nebraska landscape; preserve the view of and from Scotts Bluff; protect Mitchell Pass, which afforded emigrants a passage west without having to cross over the nearby bluffs or the adjacent North Platte River; protect the remnants of the Oregon Trail , which are still visable within the boundaries of the monument; preserve the geological features of the bluff, which are of scientif interest; preserve and interpret to monument's features for public enjoyment for generations to come; (and) preserve the scenic and historic integrity of Scotts Bluff and adjacent features.

GENERAL DESCRIPTION:
Scotts Bluff National Monument lies in the west-central portion of the Nebraska panhandle on the southern bank of the North Platte River. A prominent natural landmark for travelers on the Oregon Trail, the bluff known as Scotts Bluff is the primary feature in the 3,003-acre national monument. The site preserves the legacy of the historic Oregon, California, and Mormon Trails. Scotts Bluff NM is the most urban of all the parks in the Network. On the east boundary lies the town of Gering (pop. 7,751) and to the northeast lies the town of Scotts Bluff (pop. 14,732). The other boundaries primarily abut cultivated private lands. An exception is a sinuous ridge that connects the promontories of Scotts Bluff to the Wildcat Hills region. Three canals and associated maintenance roads are located in the park under existing agreements. A heavily used railway also bisects the park. Hunting and trapping are not allowed. Fishing occurs in the North Platte River.

DESCRIPTION OF NATURAL RESOURCES:
Native prairie comprises 48% of the land cover at Scotts Bluff NM, with barren (21%), human disturbed (15%), shrubland (8%), and forested (7%) cover types comprising smaller but significant amounts of the park (Aerial Information Systems, 1998*c*: see Table 4). The natural vegetation of the area is mixed- and short-grass prairie on the plains, pine/juniper woodlands scattered across the bluffs, and sparse to no vegetation in the badlands topography, primarily between the bluff and the North Platte River. There is debate about the extent and density of trees in the riparian corridor prior to European settlement. The 1996-97 vegetation mapping effort identified 22 vegetation types (Aerial Information Systems, 1998*c*). Of these, two are considered globally vulnerable or worse: *Central Wet-Mesic Tallgrass Prairie* and *Great Plains Natural Seep*. However, the former barely resembles the type description because of the high abundance of weeds (various brome grasses, Canada thistle, reed canary grass, and Kentucky bluegrass) and the presence of some shrubs and trees. The latter occurs in only one very small location where it is bisected by an asphalt hiking path. Other vegetation types that may be globally vulnerable include *Rocky Mountain Juniper/Little-Seed Ricegrass Woodland*, *Ponderosa Pine/Little Bluestem Woodland*, and *Cottonwood-Peachleaf Willow Floodplain Woodland*. For a more thorough discussion of plant resources at the park see Symstad (2004).

Wildlife resources in the park are relatively diverse due to the variety of habitats; however, the small size of the park precludes viable populations of several native species. For example, bison, wolves, elk, pronghorn, sharp-tailed grouse, swift fox, and black-footed ferrets are extirpated from the site. The absence of bison and elk is especially noteworthy because of their grazing effects and the absence of wolves is noteworthy because coyotes prosper in the absence of the larger canid. Bighorn sheep have recently been reintroduced in the Wildcat Hills to the south of the park and at least one individual has been briefly observed in the park. The ratio of mule deer to white-tailed deer appears to be more equal than any other park in the Network (Schmidt et al. 2004). The park has approximately 90 acres of prairie dogs. The colony is noteworthy because no other colonies exist in the vicinity of the park. Park staff view the diversity and abundance of bats in the park as a significant wildlife resource. The riparian area appears to provide excellent bat habitat (Schmidt et al. 2004). Herpetofauna richness could be as high as 25 species making it one of the most diverse parks in the Network (Smith et al. 2005). Diversity appears to be especially high in the North Platte riparian area. At least 21 fish species have been documented in the river and another seven may be present (White et al. 2002).

The park does not support any federal or state-listed species, but it does house at least 10 species on the Nebraska list of Plants of Concern (http://www.natureserve.org/nhp/us/ne/plants.html). These are: narrow-leaf milkvetch, Parry's rabbitbrush, spotted mission bells, stickseed, matted prickly gilia, Nuttall desert-parsley, stemless nailwort, spearhead phacelia, double twinpod, and flowering-straw. Two additional species, nodding buckwheat and whitestem stickleaf, have been recorded at the park, but recent field work has not found them (DeBacker, 1997). Of these twelve species, only three are not considered globally secure: stickseed, matted prickly gilia, and Nuttal desert-parsley.

About 1 mile of the North Platte River runs along the northern border of the monument and is a significant resource in the park. The hydrograph of the river, and hence the geomorphology of the site, has been altered by upstream dams, irrigation withdrawals and returns, municipal use, and other factors.

NATURAL RESOURCE GOALS AND OBJECTIVES:
The park does not have any formal natural resource goals or objectives or desired future conditions.

NATURAL RESOURCE ISSUES:
The small size of the park and the urban interface affects the park's ability to implement prescribed fire (limited burning does occur), to restore large grazing animals such as bison, and to preserve many other natural resources and processes. Park staff expect neighboring land uses to affect park resources and management into the future.

Vegetation management is a top priority for the park. Exotic plants such as cheatgrass and smooth brome will continue to be a significant conservation issue. New exotic plants such as phragmites and purple loosestrife may be an issue in the future. The forested riparian area was probably not woody at the time of the pioneers. In spite of the current conditions being inconsistent with the park's enabling legislation and NPS policies, park management recognizes there are values to the current habitat (e.g., a visual screen against urban areas outside the park). Regardless of the desired future conditions for the site, high fuel loads in the riparian area are currently a concern. The absence of grazing throughout the park is a concern to management although it does not appear to have affected species richness (Symstad in prep). Limited prescribed burns have been conducted, but implementing future burns and their effects on vegetation resources are a high concern. Parts of the park were previously cultivated or used as golf courses. Prairie plantings in these areas have met with varying success. Park staff are concerned about the impact of climate change on plant communities.

Prairie dogs are a high profile wildlife issue due to their rapid expansion (almost certainly drought induced) and the urban interface. High deer numbers in the park, and urbanization near the park boundary, have the potential for landowner complaints and vehicle collisions. Chronic wasting disease is present in extreme western Nebraska and may someday affect deer in the park. The park would like to reintroduce sharp-tailed grouse, but the small size of the park raises concerns about the likelihood of sustaining a viable population. Water quality and quantity will continue to be an issue for the park. The North Platte River is now an altered stream due to upstream dams, irrigation withdrawals, pesticide, sediment, and nutrient loads, and other factors. Park management is concerned about seepage from the canals that pass through the park and maintenance activities associated with the canals.

The railroad that passes through the north part of the park and the maintenance activities associated with it has numerous impacts on park resources (e.g., geology, air quality, sound). The Great Plains are renown for the night skies, but the urban areas next to the park have greatly degraded the quality of the night sky from the park. Air quality monitoring in the vicinity of the park is considered poor relative to other Network parks (Pohlman 2005). Visitor use, including hiking, driving, and sightseeing impacts park resources in many ways. Of special concern is the trail that passes by Scotts Spring, a valuable habitat for herpetofauna (Smith et al. 2005). The park is considering a future acquisition by Roubideax Pass and associated Oregon Trail ruts which would need to be addressed in regards to natural resources.

PARK-SPECIFIC MANDATES AND REQUESTS TO MONITOR NATURAL RESOURCES:
Implicit in the park's enabling legislation is the conservation and monitoring of the bluff, specifically, the views from and of the bluff and the Oregon Trail. Some park neighbors have expressed concerns about exotic plants, rattlesnakes, and prairie dogs.

CURRENT MONITORING PROJECTS:
Scotts Bluff NM has an active and systematic plant and prairie dog monitoring program as a result of the park being within the Prairie Cluster LTEM program. It is anticipated that this monitoring effort will continue until the Network is ready to begin field operations, at which time the Network may adopt the existing monitoring programs, a version thereof, or abandon the current efforts. The Fire Effects program has monitoring plots within the park and the EPMT surveys the presence and distribution of invasive exotic plants. The University of Nebraska-Lincoln has monitored the effectiveness of a sedge restoration site; monitoring will end in April 2005. The park has an automated weather station. Most other monitoring within the park is less intensive or unsystematic. A breeding bird and Christmas bird count is collected in and around the park by the local Audubon club. The State of Nebraska periodically takes water samples from Scotts Spring and elsewhere in the vicinity of the park. For a complete list of current and past monitoring and replicable research see Appendix D.

ADDITIONAL INFORMATION:
Detailed information on the park can be found at http://www.nps.gov/scbl/index.htm and other NPS web sites, in a historical account by Mattes (1992), and in the park's General Management Plan (National Park Service 1998).

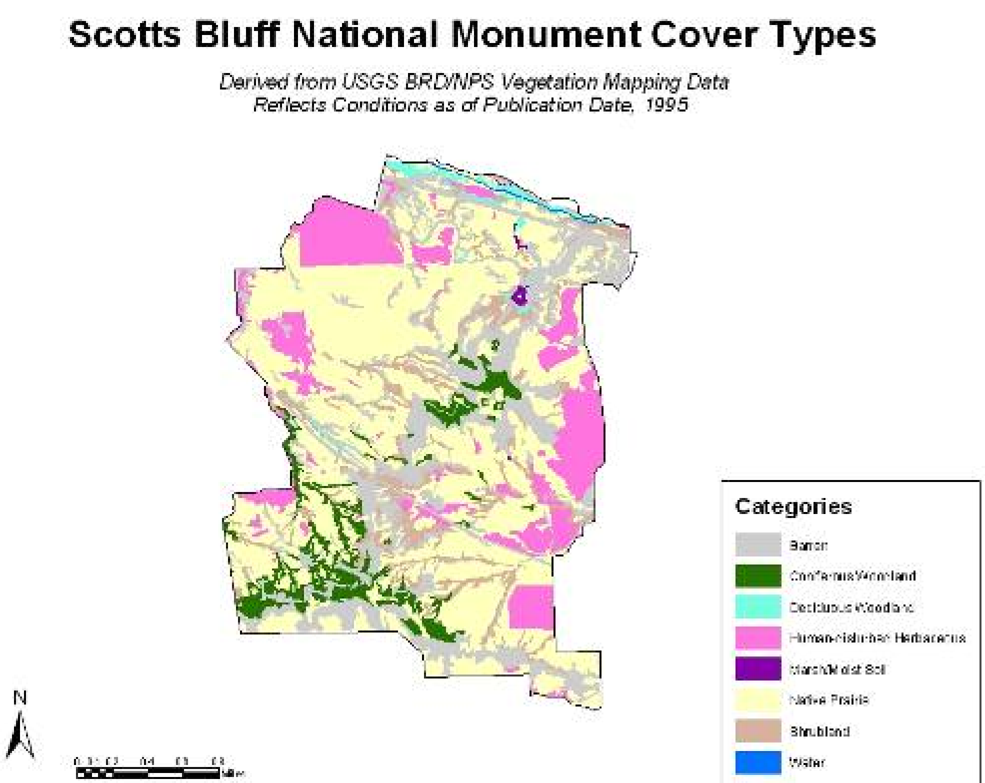

Figure 21. Scotts Bluff NM Land Cover

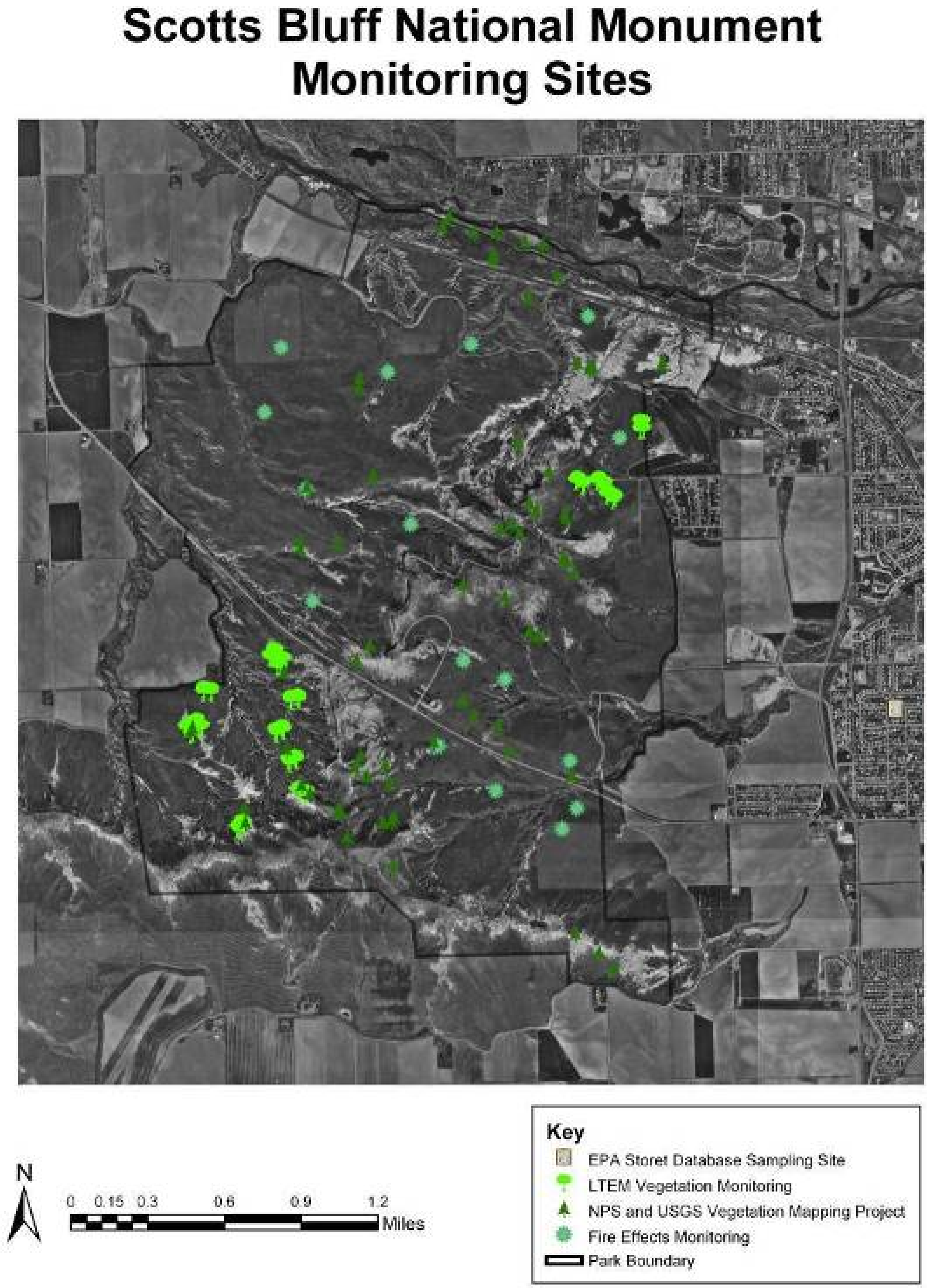

Figure 22. Scotts Bluff NM Monitoring and Research Sites

Theodore Roosevelt National Park

ENABLING LEGISLATION/HISTORICAL CONTEXT:
Theodore Roosevelt National Memorial Park was established in 1947 as a memorial to its namesake who made significant contributions to the conservation movement and the development of the West. In 1978, Congress reestablished the park as Theodore Roosevelt National Park including the Theodore Roosevelt Wilderness. From 1934 to 1947 some of the area was managed for recreational purposes by state and federal agencies. Prior to this, most of the land was used for cattle ranching.

PARK MISSION:
The park does not currently have a formal mission statement.

GENERAL DESCRIPTION:
Lying in the Little Missouri Badlands of western North Dakota, the 70,446-acre park is divided into a North Unit (24,030 acres), a South Unit (46,200 acres), and a Elkhorn Unit (220 acres). The latter is typically viewed as a cultural site. There are 19,410 acres of wilderness in the North Unit and 10,510 acres in the South Unit. A unifying feature of the three units is the free-flowing Little Missouri River that bisects the South and North Units and forms the east boundary of the Elkhorn Unit. Sightseeing from vehicles is a popular way to experience the park. Hiking and horseback riding also occur. Camping is allowed at established campgrounds and in backcountry areas. Hunting and trapping are not allowed, but do occur just outside the boundary. Fishing is not common due to the poor quality of the fishery. Surrounding lands are a checkerboard of private ranches and National Grassland properties. Almost all of the surrounding lands are grazed by cattle. Substantial energy extraction occurs in the vicinity of the park. The town of Medora (pop. 100) is on the south boundary of the South Unit and the most popular entry to the park. The town is active during the summer tourist season, but otherwise has few services.

DESCRIPTION OF NATURAL RESOURCES:
Theodore Roosevelt National Park is characterized by rugged badlands-type topography, primarily the result of prehistoric water erosion. Land cover within the park is very diverse with 40% being native prairie, 21% forest, 21% barren, and 14% shrubland (Von Loh et al., 2000: see Table 4). Dominant grass species include blue grama, western wheatgrass, and needle-and-thread. Rocky Mountain juniper is quite common on draws and hillsides, whereas cottonwood, green ash, elm, silver sagebrush, chokecherry, and aspen are more common along the Little Missouri River floodplain. Cottonwood and other riparian vegetation can be found at various life stages, typical of natural dynamic prairie streams. The 1997-1998 vegetation mapping effort documented 35 vegetation types in the park (Von Loh et al., 2000). Six of these are considered globally vulnerable or worse. Of special concern is the *Eastern Cottonwood / Rocky Mountain Juniper Floodplain Woodland* which has been documented only in the region of the park. The other five vulnerable vegetation types are *Green Ash - Elm Woody Draw*; *Prairie Sandreed - Sedge Praire*; *Ill-Scented Sumac / Thread-Leaved Sedge Shrub Prairie*; *Prairie Cordgrass - Sedge Wet Meadow*; and *Common Rabbitbrush / Bluebunch Wheatgrass Shrubland*. Lack of fire, historic overgrazing, roads and other infrastructure, and concentrations of large grazers (e.g., horses) in certain areas of the park have contributed to the degradation of vegetation resources. Numerous exotic species are found in the park with leafy spurge being the most problematic. Canada thistle is less widespread, but it is mostly locally problematic, particularly in more mesic areas. Non-native grasses and some legumes (alfalfa) were historically planted as pasture or cover in disturbed road right-of-ways. Some of these species have spread outside of their originally planted areas. For example, Kentucky bluegrass and smooth brome occur extensively in the east side of the South Unit (Von Loh et al., 2000). Other widespread problem species include yellow and white sweetclover. Despite these problems, only 2% of the park was classified as a vegetation type dominated by non-native species. It’s notable that the portion of the South Unit south of Interstate 94 does not support elk, horses, or bison and could be used as a control for purposes of monitoring herbivory. For a more thorough discussion of plant resources at the park see Symstad (2004).

The park is known for its wildlife, especially its assemblage of large mammals. Free-ranging herds of bison were re-introduced to the South and North Units in 1956 and 1962, respectively, and elk were reintroduced to the South Unit in 1985. Mule deer, white-tailed deer, pronghorn, and a small number of bighorn sheep also occur. Mountain lions are present, but not well documented. The South Unit supports a free-ranging herd of horses and part of the North Unit contains a small herd of long-horn cattle for cultural purposes. Other noteworthy mammals include approximately 1,235 acres of black-tailed prairie dogs and an extremely high density of coyotes. Amphibian diversity is limited by a lack of water; however, species are found near the Little Missouri River and the natural springs during the summer months. Several species of fish inhabit the Little Missouri River with plains minnows and white suckers particularly common. The U.S. Fish and Wildlife Service is trying to restore the sturgeon chub to the river. Bird diversity is high relative to other parts of the region due in part to the diversity of habitats within the park. Burrowing owls and a few golden eagle nests are documented in the park every year.

The park contains no federally-listed endangered or threatened species. A rare plant survey conducted in 1989 (Heidel 1990) yielded five species currently on the North Dakota Rare Plants List: smooth goosefoot, nine-anthered dalea, Rocky Mountain spurge, lanceleaf cottonwood, and alkali sacaton. Comparison of the park's plant list to the current North Dakota Rare Plants List yielded one other rare species that has been confirmed in the park, white locoweed. With the exception of smooth goosefoot, all of these species are considered globally secure. Smooth goosefoot, lanceleaf cottonwood, and alkali sacaton are also on the USDA Forest Service's sensitive species list for the region. The bald eagle, a federally-listed threatened species, is a transient in the park, and the only federally-listed wildlife species.

The 21 miles of Little Missouri River are a significant resource in the park. In addition to the river, 268 miles of intermittent drainages have been mapped (USGS National Hydrography Dataset). Impoundments and other artificial watering structures occur in portions of the park, a legacy from the ranching period. The estimated surface area of the impoundments is 5.3 acres (USGS National Hydrography Dataset). The park has great significance for conservation in the Northern Great Plains. For example, the park is a relatively natural system without cattle grazing. Woody draws are considered healthy and natural compared to similar areas outside of the park. Light grazing within the park also results in later grassland seral stages compared to the nearby private lands and national grasslands. The park's prairie dog complexes are larger than most in the region. The park is a Class I airshed.

NATURAL RESOURCE GOALS AND OBJECTIVES:
The park does not currently have explicit resource goals or objectives or desired future conditions.

NATURAL RESOURCE ISSUES:
The degradation of park resources due to exotic species such as leafy spurge, brome grass, and Canada thistle is a high priority for park management. The spread of these plants can displace native flora and indirectly affect other resources such as ungulates. Since the control of exotic plants does not necessarily result in reestablishment and recovery of native flora, monitoring the effectiveness of treatment is a high priority for the park.

The park is preparing a wildlife management plan that will identify management objectives and strategies for elk. Plans for bison, mule and white-tailed deer, bighorn sheep, pronghorn, horses, and other wildlife are needed. The State of North Dakota is especially interested in elk management at the park because of complaints by local landowners, implications for hunting, and potential for chronic wasting disease. Horses are not native to the park, but are viewed by some as a cultural resource. Their presence may conflict or compromise management objectives for other species. The Little Missouri River is listed as a 303(d) water impaired by pathogens in all three park units.

Park staff stated that habitat fragmentation may be a bigger issue in the future due to the fragmentation of ranches into smaller ranchettes and hobby ranches. Other issues that will continue to occur in the future are noxious weeds, visibility and air quality due to energy development, water quantity due to irrigation for crops and a recently constructed golf course, the viewscape and soundscape, lack of fire in the park, and overabundant ungulates due to the absence of natural predators.

PARK-SPECIFIC MANDATES AND REQUESTS TO MONITOR NATURAL RESOURCES:
The park's enabling legislation does not explicitly require monitoring of natural resources. However the park is a Class I airshed which requires monitoring of air quality.

CURRENT MONITORING PROJECTS:
Theodore Roosevelt National Park has an active natural resource program with 32 distinct monitoring programs currently being conducted in the park. However, there are some noteworthy gaps. For example, numerous vegetation plots have been established in the park over the years (e.g., Butler 1995); however, none have been monitored long term (see Appendix D). Current vegetation monitoring consists primarily of mapping the distribution of noxious non-natives the monitoring conducted by the Fire Effects program. There are some herbivore exclosures in the park, but there are questions about their integrity.

The park has numerous long-term datasets for wildlife. Prairie dogs are monitored every few years by walking the edge of the towns with GPS units. There is periodic to regular monitoring of the large ungulates in the park. Bison, elk, and horses are monitored via periodic roundups, which provide an opportunity to collect information on herd demographics as well as genetics and disease. Ground and/or aerial surveys are also conducted by the park or the State of North Dakota to monitor these species as well as mule deer and bighorn sheep. The USGS-BRD Amphibian Research and Monitoring Initiative (ARMI) program has collected 2 years of amphibian data at the park. The park was selected in part because of the existence of a PRIMENET air quality station. The park conducts a Christmas bird count and tracks golden eagle nests. The State of North Dakota supplies gypsy moth traps that the park puts out.

The park has 10 distinct stations for monitoring weather and air quality. Examples include a National Atmospheric Deposition Program station, a Gaseous Pollutant Monitoring Network station, and a Clean Air Status and Trends Network station in the South Unit near the Painted Canyon Visitor Center, and a State Air Quality Station in the North Unit. The park is the only site in the Network that has an automated digital camera system for monitoring visibility (http://www2.nature.nps.gov/air/WebCams/parks/throcam/throcam.htm). Weather stations include a NOAA Climate Reference Station in the South Unit. Although there is a weather station in the North Unit, the park would like more sophisticated equipment at the site. In terms of water monitoring there is a USGS flow gauge in Medora and another at Watford City; however the latter may be discontinued. Some studies have occurred for fish species, water quality, and pesticides (e.g., Tordon); however, there is no long-term systematic monitoring of water quality. The park has good information on the number of visitors; however, the tracking of trail use is considered to be poor. The park has established photo points in both units which go back 4-5 years.

ADDITIONAL INFORMATION:
Detailed information on the park can be found at http://www.nps.gov/thro/index.htm and other NPS web sites, in an administrative history by Harmon (1986), in a popular account by Schoch and Kaye (1993), and in the park's General Management Plan (National Park Service 1987).

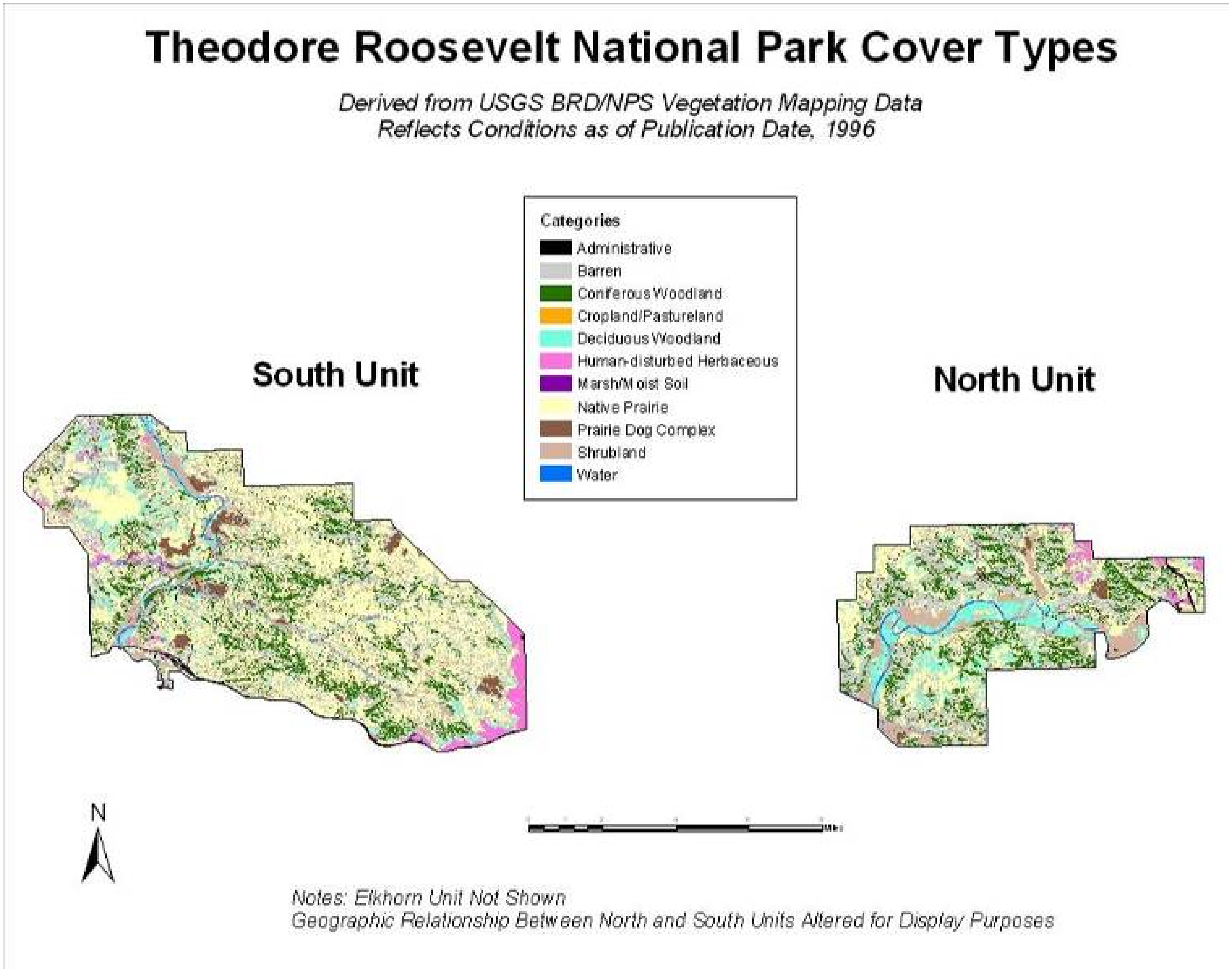

Figure 23. Theodore Roosevelt NP Land Cover

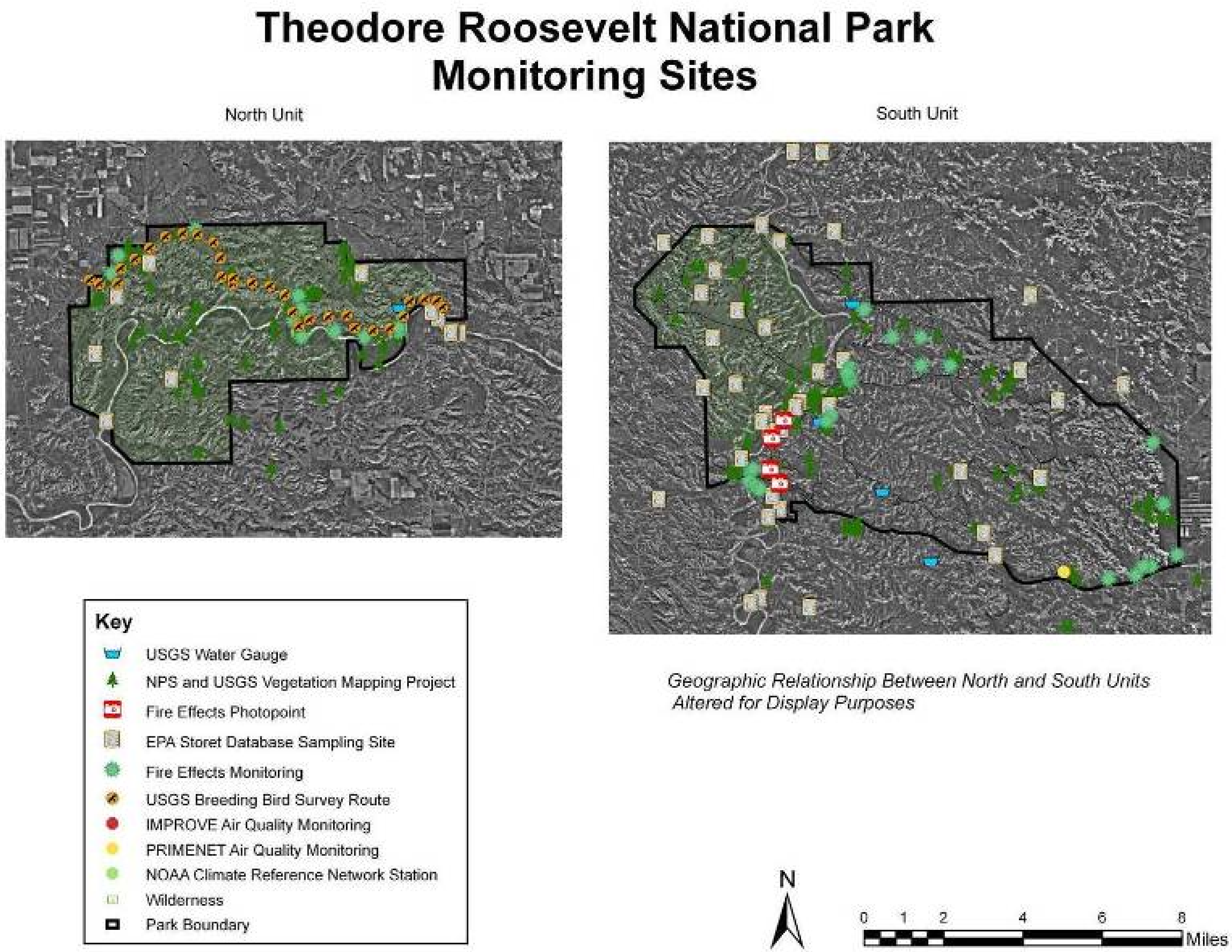

Figure 24. Theodore Roosevelt NP Monitoring and Research Sites

Wind Cave National Park

ENABLING LEGISLATION/HISTORICAL CONTEXT:
Wind Cave National Park was established in 1903 to preserve and protect Wind Cave. In 1912 the Wind Cave National Game Preserve was established on a portion of the original park and adjoining lands. Bison, elk, and pronghorn were shipped to the preserve soon after. The Preserve ultimately became part of Wind Cave NP in 1935. Since 1903, the park has grown from its original size of 10,532 acres to its present size of 28,295 acres.

PARK MISSION:
The purpose of Wind Cave National Park has evolved from cave preservation to preservation and protection of both surface and subsurface ecosystems. This allows for scientific research and provides for public use and enjoyment in ways that leave the resources unimpaired for future generations (GMP 1994).

GENERAL DESCRIPTION:
Wind Cave National Park is a 28,295-acre park on the southeastern edge of the Black Hills in southwestern South Dakota. The park is bordered by the Black Hills National Forest, Custer State Park, and private land, primarily ranchland. Visitation is high, but much of it consists of cave tours and sightseeing from vehicles. Hiking is allowed and several trails are established. Camping is allowed in designated campground and backcountry portions of the park. Hunting and trapping are not allowed, but do occur on adjacent lands. Fishing is not common due to the small size of the streams. The town of Hot Springs (pop. 4,129) lies 10 miles to the south.

DESCRIPTION OF NATURAL RESOURCES:
The park includes samples of all five of the major geomorphic divisions of the Black Hills (Central Crystalline Core, Limestone Plateau, Minnelusa Foothills, Red Valley, and Cretaceous or “Dakota” Hogback), providing a diversity of habitats. Wind Cave NP is approximately 60% native prairie, 29% forest, and 8% shrubland (Cogan et al. 1999: see Table 4). Human disturbed and administrative areas comprise only 1% of the park making the unit one of the least disturbed sites in the Network based on cover types.

The vegetation of the park was mapped using NVCS standards in 1997-1999, yielding 24 vegetation types (Cogan et al., 1999). Three of these are ranked as globally vulnerable or worse: *Cottonwood / Western Snowberry Woodland*; *Box-elder / Choke Cherry Forest*; and *Prairie Cordgrass - Sedge Wet Meadow*. All of these are quite small, comprising less than 0.5% of the park. Seven other vegetation types may also be globally vulnerable. The Black Hills Community Inventory (Marriot et al. 1999) evaluated the condition of 22 vegetation types at the park. Of these, 10 were ranked as “A” (the highest integrity), 8 as “AB”, and 4 as “B”. As a result, the inventory considered the Wind Cave NP to be one of eight “exemplary” sites in the Black Hills. Only two vegetation types classified by the vegetation mapping effort (Cogan et al., 1999) were dominated by non-native species: they were *Introduced Weedy Graminoid Herbaceous Vegetation* and *Kentucky Bluegrass Herbaceous Vegetation.* The former, characterized by smooth brome, cheat grass, and Japanese brome, amounted to only 6.7 acres in the park, but the species that characterize this type are sometimes found in other vegetation types. The latter could not be separated from native grassland from aerial photograph interpretation, but is extensive in the eastern half and southwestern quarter of the park (Cogan et al., 1999). Kentucky bluegrass also occurs in other vegetation types. Other non-native species of note are common mullein, yellow sweetclover, and Canada thistle. In general, these occur locally and are often associated with disturbance, such as dense patches of common mullein following high intensity fires. Park personnel began a prescribed fire program in 1973 (Forde et al. 1984). Although this has probably helped slow the spread of pine into grasslands, it probably does not mimic the pre-European settlement fire regime. As a result, plant communities, particularly those in the pine woodlands and forests, have probably been impacted. For example, comparison of aerial photos from the 1930's to current times suggests that tree density has increased (D. Foster, pers. comm.). For a more thorough discussion of plant resources at the park see Symstad (2004).

Many wildlife species associated with the mixed-grass prairie ecosystem occur at the park. These include large ungulates such as bison, elk, deer, and pronghorn. These ungulates essentially have access to all portions of the park. The bison are especially noteworthy because they are free of cattle genes, making them especially important for conservation of the species. The elk are a high profile species due to concerns of CWD and hunting outside the park. The black-tailed prairie dog—a keystone prairie species—is common and exists in large complexes. Predators such as coyotes, bobcats, mountain lions, golden and bald eagles, and rattlesnakes are present and recognized as valuable components of the ecosystem. Bird diversity is high due to the diversity of habitats (Panjabi 2005). Seven fish species have been documented, including non-native brook trout (White et al. 2002).

The park does not support federally-listed threatened or endangered species. A rare plant survey conducted in 1998 (Marriot 1999) confirmed the presence of four species on the South Dakota Natural Heritage Rare Plants list; they are nylon hedgehog cactus, Hopi tea, Easter Daisy, and Hooker's Townsend-daisy. All of the species are globally secure. Two other species (interrupted wild rye and sleepy grass) were previously recorded in the park, but were not found in 1998. The park's plant list also includes smallflower columbine and American cranberrybush, Forest Service sensitive species monitored by the Black Hills National Forest. Bald eagles occur occasionally, especially during the winter, and are the only federally-listed endangered or threatened species that currently occurs in the park. One land snail and several birds and bats in the park are on the state list of species of concern.

The USGS National Hydrography Dataset mapped 7.51 miles of perennial stream in the park and 63.50 miles of intermittent streams. The perennial streams disappear underground for portions of their length, especially during dry periods. The cave is a significant natural resource for the park and is globally renowned. It is the fifth longest cave in the world and is known for the boxwork formations. Wind Cave NP is very important in terms of regional biological diversity. It’s considered one of the few places where the major ecosystem processes that shaped the vegetation of the Black Hills before European settlement are relatively intact (Marriot et al. 1999). The park provides a mosaic of burned areas with a diversity of species composition, structure, and function. Large snags are common within the park in contrast to much of the Black Hills. The burning is complemented by the comparatively light grazing of ungulates, resulting in conditions rarely found in the Northern Great Plains. The large size and protected status of the prairie dog complex make it important regionally. The park is a Class I airshed.

NATURAL RESOURCE GOALS AND OBJECTIVES:
The park does not currently have explicit resource goals or objectives or desired future conditions, although such statements may be developed as part of current planning efforts.

DESCRIPTION OF NATURAL RESOURCE ISSUES:
As is the case in all parks in the Network, exotic plants are a significant natural resource issue at Wind Cave NP. Although the park has an active treatment program, the effectiveness of these efforts are not systematically monitored. Park staff are concerned that the current level of elk browsing is preventing hardwood regeneration, particularly aspen. Unnatural fire patterns may also play a role in the hardwood decline, as well as stressing other vegetation resources.

Wind Cave has numerous issues related to wildlife. Because the park is mostly fenced, the bison and elk populations are closed and semi-closed, respectively. Both species have traditionally been rounded up and culled to keep within range objectives; however, the recent occurrence of CWD has foreclosed that option for elk and there are concerns about being able to find recipients for surplus bison in the future. Overabundance of either species could have negative impacts on other park resources and objectives. The pronghorn population has declined dramatically from past levels (350 in 1963 to 60 in 2004). Prairie dogs continue to be a high management priority because of their role as a keystone species, concerns by neighbors, and the potential for black-footed ferret reintroduction. A small number of exotic fauna occur in the park, including brook trout in the streams and the occasional feral cat. Documented wildlife diseases such as CWD and tularemia, and undocumented diseases such as plague and West Nile virus, are an issue, both from the perspective of ecological impacts and human health.

Surface water quality and quantity are a concern for management. There is evidence that surface water flows in the Black Hills have been reduced from historic levels due to development and land use practices. Fish kills have been observed in recent times in Highland Creek. The integrity of the cave is a high management issue because of the cave’s global significance and the park’s enabling legislation and intent. Runoff of degraded water from the visitor center parking lot was affecting cave resources, but a recently reconstructed lot may have mitigated that impact.

The presence of people in the cave, both visitors and park staff, can affect cave integrity, as can the associated infrastructure (e.g., lights). Development and land use adjacent to the park is a concern to park staff. Other issues include air quality impacts as a result of energy development in Wyoming as well as from other sources, the small size of the park which precludes some management options and exacerbates boundary conflicts, and visitor stress to wildlife and other park resources.

The park envisions most of these issues continuing into the future. Another potential future development is that the park may acquire several thousand acres along the south property. The land has a history of CWD; however, the site contains spectacular geologic and floral resources.

PARK-SPECIFIC MANDATES AND REQUESTS TO MONITOR NATURAL RESOURCES:
The conservation of bison, elk, and pronghorn is explicitly mentioned in the park's enabling legislation. Implicit in this is the monitoring of abundance and viability. The park will jointly develop an elk management plan with the State of South Dakota; the plan may have a monitoring component. The U.S. Fish and Wildlife Service would like to see prairie dog monitoring continue, especially if the park should reintroduce ferrets. The U.S. Forest Service has a bird monitoring program in the Black Hills they would like the park to contribute to. Custer County would like the park to control exotic plants; implicit in this is some level of monitoring. The park is a Class I airshed.

CURRENT MONITORING PROJECTS:
Several vegetation monitoring projects are being conducted at Wind Cave NP, although all are fairly recent initiatives. The distribution of noxious exotic plants is being mapped by the park and the EPMT as a part of control efforts. A "scorecard" system provides a quick assessment of the seral stage of park vegetation. The Fire Effects program monitors vegetation response to fire. The park monitors forage availability and range conditions. A Forest Inventory Analysis (FIA) plot is located in the park. Photo points have been established in the park. The park has several ungulate exclosures established either for hardwood regeneration and/or ungulate browsing studies.

In terms of wildlife monitoring, the park has 16 distinct monitoring programs. Bird monitoring includes a Breeding Bird Survey route run since 1997, bird transects run by park staff, Christmas bird counts, and specialized surveys for owls, sharp-tailed grouse, and raptors. There are eight distinct mammal monitoring projects including monitoring of bison, elk, pronghorn, prairie dogs, and bats. Monitoring elk for CWD and coyotes for a suite of diseases are recent monitoring initiatives. Informal monitoring of tiger salamanders and gypsy moth monitoring complete the current fauna monitoring. A replicable cave biota study is being started.

Monthly water quality measures are collected at several perennial streams (Beaver, Highland, Cold Spring) by park staff. There is a USGS flow gauge station on Beaver Creek which is managed by USGS. Water levels in the cave are monitored monthly. Micro-climate, dust, and radon measurements are also taken in the cave. Visitor use of the cave is well monitored. A recently completed parking lot construction project includes associated water quality monitoring. The park has recently installed IMPROVE, CASTNET, and NADP stations for air quality monitoring and has collaborated with the State of South Dakota in regards to the monitoring program. Visitor use of hiking trails is not monitored; however, overnight visitors are required to get permits. Traffic counters monitor vehicles on the highway. See Appendix D for a complete list of past and current monitoring projects and replicable research projects.

ADDITIONAL INFORMATION:
Detailed information on the park can be found at http://www.nps.gov/wica/index.htm and other NPS web sites, in the official handbook for the park (National Park Service 1979), in a popular account of the park by Terry (1998), in a natural history of the Black Hills by Raventon (1994), and in the park's General Management Plan (National Park Service 1994*b*)

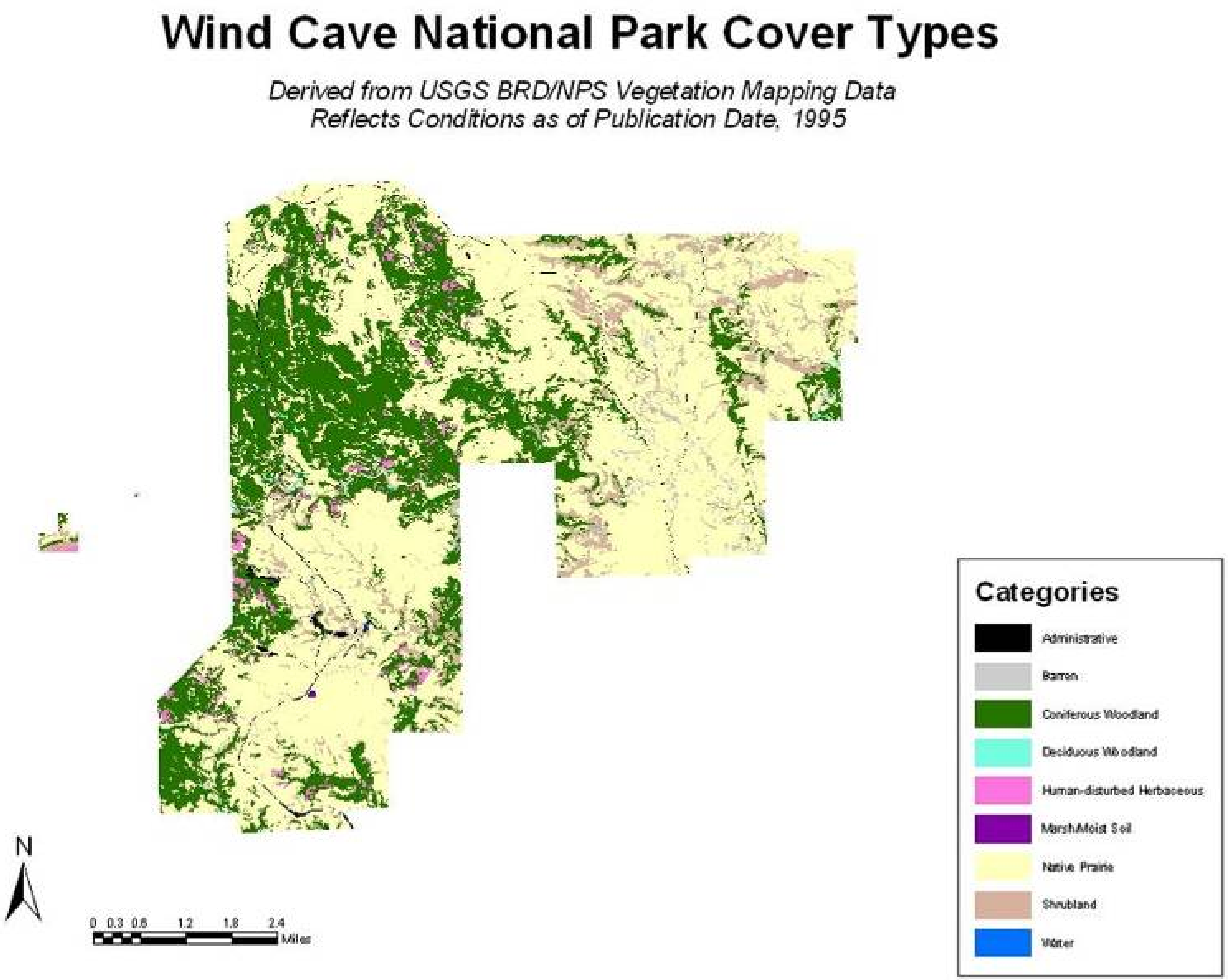

Figure 25. Wind Cave NP Land Cover

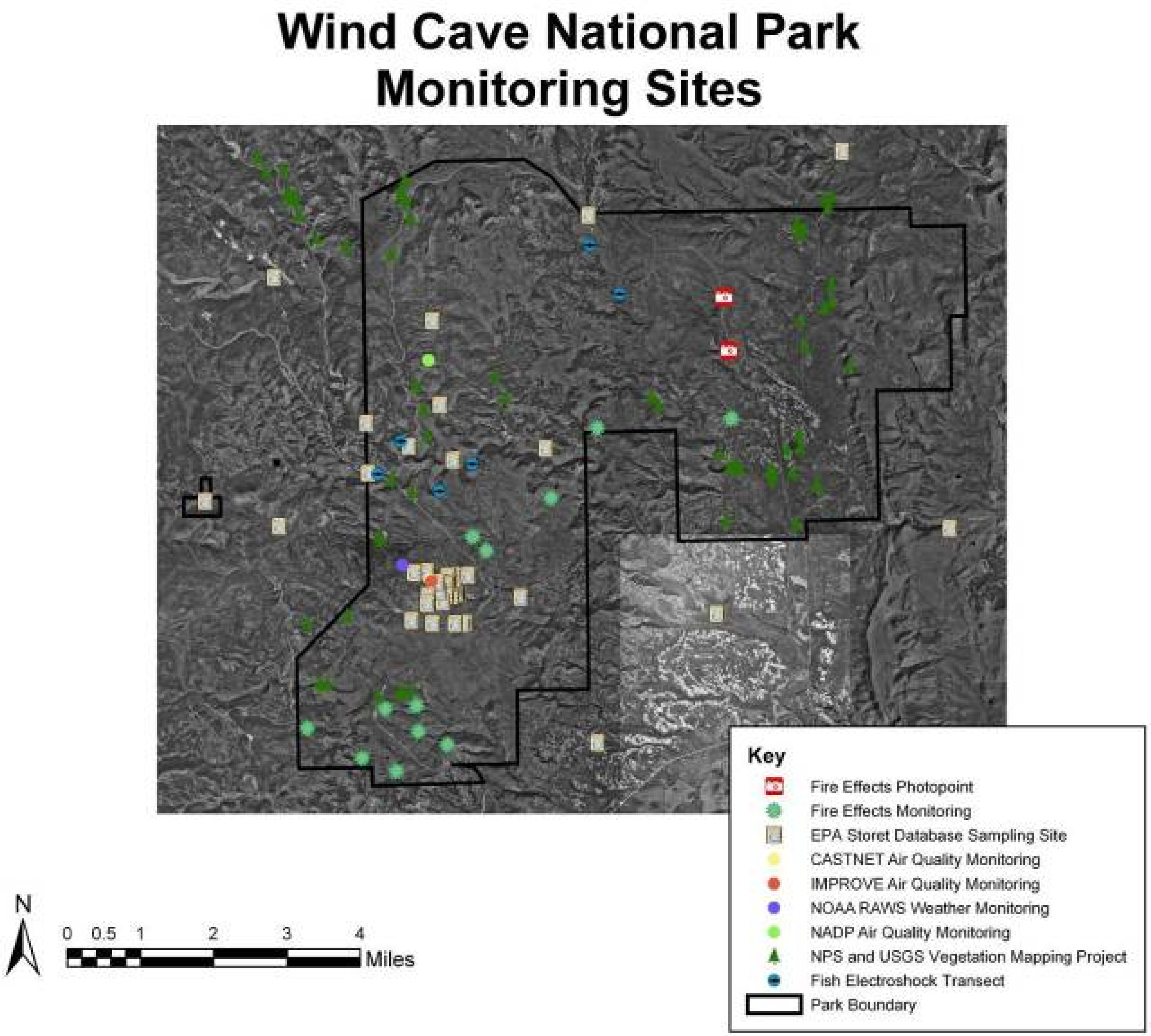

Figure 26. Wind Cave NP Monitoring and Research Sites

BACKGROUND ON MONITORING PLANNING ACTIVITIES TO DATE

Several parks in the Northern Great Plains Network explored long-term ecological monitoring even before the national I&M Program was developed. For example, in the early 1990s Plumb (undated) described a monitoring approach for Badlands NP, Devil's Tower NM, Theodore Roosevelt NP, and Wind Cave NP that included a program budget, organization chart, and data management outline. And Scotts Bluff and Agate Fossil Beds NMs are part of the Prairie Cluster LTEM program which started in the early 1990s (Thomas et al. 2001). Several parks have ongoing long-term monitoring programs and datasets for select resources.

The groundwork for developing a Vital Signs monitoring program for the Network began with the data mining and biological inventory efforts started in FY99. At that time the Network I&M Program was located at Theodore Roosevelt NP. In 2001 the acting program coordinator resigned and the new coordinator was subsequently duty stationed at Badlands NP. In 2002 the coordinator moved to Mt. Rushmore NMEM.

Since its establishment the Network has placed an emphasis on data mining, synthesis, and analysis. Reports, data, and other information from park files have been compiled and, when appropriate, entered into national databases such as NPSpecies. Hard copy documents have been scanned or otherwise entered into digital format. The Network expanded its data mining efforts beyond just park-housed information by conducting searches of ecological and natural resource databases and bibliographies, museums, and the internet, and soliciting information from subject-matter experts and other agencies and organizations. As a result of these data mining activities, the Network identified, developed, and contracted for a variety of biological inventories to address knowledge gaps. Specifically, these inventories were conducted to document at least 90% of the vertebrates and vascular plants expected to reside or breed in the parks (Table 7). In addition to these baseline studies, Lepidoptera inventories were conducted because of the conservation concerns and management implications of invertebrates in small parks. Aquatic macro-invertebrate inventories were conducted as part of a larger water quality planning project (see below). The Network has contracted with several subject-matter experts to certify species lists for each park.

Table 7. Biological Inventories Funded by I&M Program

Park	Birds	Fish	Herps	Mammals	Plants	Lepidoptera
Agate Fossil Beds NM				X		X
Badlands NP						
Devils Tower NM	X	X	X	X		X
Fort Laramie NHS	X	X	X	X	X	X
Fort Union Trading Post NHS	X		X	X	X	X
Jewel Cave NM	X		X	X		X
Knife River Indian Villages NHS	X		X	X		X
Missouri NRR			X	X	X	
Mount Rushmore NMEM	X	X	X	X	X	X
Niobrara NSR			X			
Scotts Bluff NM		X	X	X		X
Theodore Roosevelt NP						
Wind Cave NP	X	X		X		

The Northern Great Plains Network is last in the NPS funding sequence for Vital Signs (i.e., monitoring) funds (although it may get full funding as part of a last group of networks). The Network received $150,000 in startup funds in FY03 and FY04. The Network used the monitoring funds to pay for a Network Coordinator, a Data Manager, and several technician-level positions. The Network also used the funds to establish agreements with other entities to develop portions of the Vital Signs monitoring plan. Specifically, in FY04 the Network funded an agreement with Dr. Nels Troelstrup of South Dakota State University to develop the water quality monitoring portion of the Network's monitoring plan. Dr. Troelstrup and his staff have met with staff of each park to discuss water quality issues and stressors. They have also conducted bioassessments at each park and collected baseline water quality data in the vicinity of each park. The project is scheduled to be completed in 2006. The Network also established a non-funded agreement with Dr. Amy Symstad of USGS-BRD to develop the plant monitoring portion of the Vital Signs plan. Much of this project, specifically the data mining portion, identification of stressors, and tentative identification of Vital Signs, has already been completed (Symstad 2004). In 2005 the project will explore and test vegetation monitoring protocols in collaboration with the NGP Fire Effects Program and the NGP EPMT. The ultimate goal is a vegetation monitoring protocol that meets the needs of all three programs and maximizes efficiency and coordination between the programs. David Pohlman of the Midwest Regional Office of the NPS prepared a report on air quality and air quality monitoring in the Network (Pohlman 2005) and will assist with developing the air quality portion of the plan. These three projects have significantlt moved the Network monitoring program forward. Additional information is at http://www1.nature.nps.gov/im/units/ngpn/Pages/monitoring.htm.

In 2003-04 the I&M Program Coordinated conducted a Vital Signs planning meeting with each park in the Network (this meeting preceeded the water specific and plant specific meetings described above). The meetings typically consisted of I&M Program staff and senior and natural resource staff from the park. The purposes of the meeting were to 1) inform park staff of the I&M Program, 2) get input from park staff on important natural resources, 3) get input from park staff on stressors to those resources, and, 4) determine goals and objectives for the Network I&M Program. Based on feedback from these scoping meetings it was determined that vegetation and water quality monitoring would likely be conducted in most if not all Network parks. Therefore, another round of park-specific meetings were held for both vegetation resources (see Symstad 2004) and water resources (Troelstrup, in prep.).

In addition to these park-specific meetings to identify resources, stressors, and preliminary Vital Signs, the Network Board and Technical Committees (see below) have had numerous meetings and conference calls (see http://www1.nature.nps.gov/im/units/ngpn/Pages/Organization/meetingMinutes.htm). Furthermore, the entire Network, including park superintendents and resource staff, has met annually since 2001. The Network expects to have a Network-wide Vital Signs identification meeting in the fall of 2005 with participation by outside experts.

The Network I&M Program uses a variety of tools to communicate to parks and other interested parties. For example, the Network has developed a dynamic web page (http://www1.nature.nps.gov/im/units/ngpn/index.htm). The I&M Program also disseminates monthly reports on the status of the program to Network parks and others (see the web page above for an archive of monthly newsletters). The Network has also presented information at university seminars and professional workshops and conferences (Symstad and Licht 2004, Licht 2005). These efforts have promoted the program and established critical contacts.

In 2003 and 2004 the Network established a Board of Directors (Board) and a Technical Committee. The Board is comprised of 3 superintendents from the network who serve on a rotational basis, plus the Network and Regional I&M Coordinators who are non-voting members. The Committee is comprised of one representative from each park in the Network, plus the Network and Regional I&M Coordinators. More information on the organization and operation of the Network's I&M Program can be found in Chapter 8 or see the Network web page.

OVERVIEW OF MONITORING IN AND NEAR NETWORK PARKS

Ecological monitoring in the vicinity of Network parks ranges from minimal to non-existent. Although many monitoring initiatives have been designed or started within the parks, many have also fizzled out and died due to a lack of funding, changing priorities, or changes in personnel. NPS programs that started in the 1990s, such as the LTEM prototypes and the Fire Effects monitoring program, are the most systematic monitoring conducted in the parks, especially in regards to plant resources. Modern air quality monitoring stations are now in place at four parks in the Network. And the three large parks have usable long-term data sets on bison and a small number of other wildlife species. However, no park has a comprehensive and scientifically defensible long-term data set that allows them to make inferences about ecosystem health and changes over time. For a detailed list of monitoring in and near parks see the discussions of the individual parks earlier in this chapter or Appendix D. This section briefly summarizes regional monitoring iniatives.

The Northern Great Plains does not have any long-term comprehensive ecological monitoring sites or research sites with a monitoring component. The Konza Prairie Long-term Ecological Research (LTER) Program in eastern Kansas lies to the south and east of the Northern Great Plains and is in a tallgrass ecosystem (see Knapp et al. 1998). The Shortgrass Steppe Long-term Ecological Research Program in eastern Colorado is also outside of the Northern

Great Plains Network and in an ecosystem that is only marginally represented in the Network parks. There are several university research stations scattered throughout the Northern Great Plains that conduct monitoring type activities, but none on the scale of the LTERs mentioned above.

State agencies in the Northern Great Plains conduct some monitoring, generally for wildlife (specifically, game species such as deer, game birds, and game fish), water, and air resources, but they are poorly funded compared to many states outside of the region. The state wildlife agencies are all in the process of developing comprehensive wildlife management plans that will include monitoring components. The Network expects to collaborate closely with the states in these efforts. The region does have a good network of air quality monitoring sites overseen by state agencies (Figure 27: see Pohlman 2005). The numerous stations are partly due to the prevalence of the energy industry in the region.

Many of the federal monitoring programs are also poorly funded and of marginal quality. For example, the national grasslands have very little monitoring (see Symstad 2004 for a discussion of vegetation monitoring programs in the vicinity of Network parks) although there are some new iniatives on some grasslands (e.g., bird monitoring with variable distance point counts on the Little Missouri National Grasslands in North Dakota). The Black Hills National Forest conducts monitoring as part of the Forest Inventory Analysis; however, those efforts are best suited to landscape level analysis and primarily focus on vegetation. The Black Hills National Forest does conduct some wildlife monitoring, including a landscape level bird monitoring effort that the Network I&M Program has collaborated with. The Fish and Wildlife Service has periodically sampled fish and other aquatic resources in streams in North Dakota, but the effort is not very robust.

Some of the better and more systematic monitoring in the region is the vegetation monitoring conducted by The Nature Conservancy. However, with the exception of a preserve located almost entirely within the Niobrara NSR, most of these sites are some distance from Network parks.

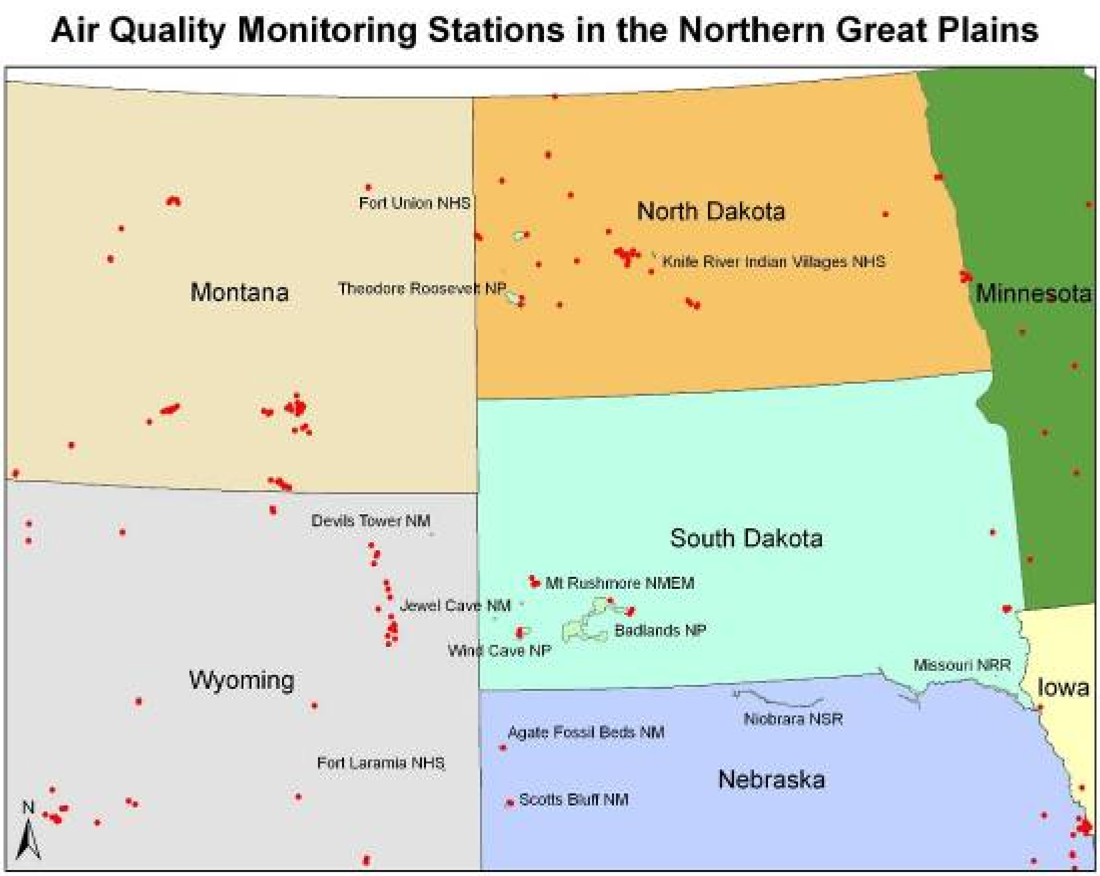

Figure 27. Air Quality Monitoring Stations in the Northern Great Plains Network

CHAPTER 2. CONCEPTUAL ECOLOGICAL MODELS

INTRODUCTION

Conceptual ecological models can improve and communicate understanding of how natural systems work. Models are typically a visual or narrative summary that describe the components of interest in a system and their juxtaposition, relationships, and strengths (National Park Service 2003). Because natural systems are complex, ecosystem models need to be a simplified representation of those systems for the model to be comprehensible. Conceptual models not only organize information and understanding, they can validate or refute the role of components, structure, and processes in a system. They are heuristic in that they can lead to greater understanding and the identification of information deficiencies. The development of conceptual models can promote integration and communication among scientists, managers, and decision makers. The best conceptual models can be everyday tools used in the process of developing and implementing a natural resources monitoring program. The Northern Great Plains I&M Network developed conceptual models with the following objectives in mind:

1. Formalize our understanding of park ecosystems
2. Clearly communicate our understanding of park ecosystems to a wide variety of audiences
3. Identify the spatial, jurisdictional, and logistical bounds of park systems
4. Identify anthropogenic stressors affecting ecosystem integrity
5. Include resources of high priority to park management
6. Have a level of resolution and information that facilitates identification of Vital Signs
7. Facilitate the identification of management thresholds and actions
8. Provide future benefits such as planning, decision making, and research

The Network developed seven ecological models to meet the objectives. The models range from simple to complex. One is narrative while the others are primarily graphical. Several focus on a particular resource or community whereas others are issue oriented. Some are "control models" in that they show feedback and interactions between particular resources, whereas other models do not show linkages. However, what all of the models have in common is that they aid understanding of park resources and issues. The models are:

- Biodiversity Model
- Nutrient Model
- Bison and Other Wildlife Relationships Model
- Disturbance Model
- Land Use Change Model
- Terrestrial Ecosystem Model
- Aquatic Ecosystem Model

> *All things are connected, this we know.*
> *Chief Seattle*

Several of the models use specialized terms. A misunderstanding of these terms can lead to confusion, frustration, and dissatisfaction. The NGPN uses the following terminology for the ecological models:

Driver — The driving forces that exert a large-scale control on the system. Drivers used in the Northern Great Plains I&M Network models are natural in origin (this definition contrasts with some other definitions which include anthropogenic drivers). Examples are fire, weather, and landforms.

Stressor — The perturbations to a system that are (a) foreign to that system and/or (b) natural to the system but applied at an unnatural level due directly or indirectly to anthropogenic actions. Examples of anthropogenic stressors include water withdrawal, pesticide use, emissions from energy development, and the extirpation of top-level predators and ungulates. The NGPN made a conscious effort to clearly differentiate anthropogenic stressors from natural stressors due to the confusion sometimes caused by the word *stressor* when it is not qualified.

BIODIVERSITY MODEL

Current National Park Service policies were established and institutionalized in the document *National Park Service Management Policies 2001* (National Park Service 2000*b*). These policies are the primary guidance on how parks should manage their natural resources. They are also a good basis from which to develop the first ecological model relevant to park units in the Northern Great Plains I&M Network.

National Park Service policies call for parks to manage for *natural conditions*. NPS policies define *natural conditions* as the "condition of resources that would occur in the absence of human dominance over the landscape" (National Park Service 2000*b*:28). Although not explicitly stated in the policies, such a definition is often viewed synonymously with pre-European conditions. Therefore, the *natural condition* for a park is the default desired natural resource condition (however, a park's enabling legislation may supercede that guidance and require management for cultural resources or conditions, e.g., for a certain time period). In other words, a healthy park is one that maintains *natural conditions*. Hence, a goal of natural resource monitoring should be to measure and assess whether a park is meeting these policies of maintaining natural conditions. Monitoring components of natural conditions (e.g., species richness) can be an end point in itself. Although a clear understanding of natural conditions is sometimes elusive, inferences and conclusions can be made from historical accounts, studies that reconstruct past events (e.g., tree ring analysis), natural history studies, and ecological theory and principles (see Swetnam et al. 1999).

The NPS policy of conserving natural conditions is similar to definitions of conserving biological diversity or biotic integrity. Biological diversity, also known as biodiversity, is most simply described as the variety of life, although numerous other definitions exist (DeLong 1996). Biodiversity is often defined as having three components and three hierarchical levels (Table 8). Some definitions add spatially-explicit definitions such as alpha (within habitat), beta (between habitats), and gamma (regional) diversity. The various components of biodiversity can often be measured, hence making them suitable as Vital Signs. Indeed, the NPS monitoring program defines Vital Signs using standard biodiversity definitions when it says that Vital Signs "may occur at any level of organization including landscape, community, population, or genetic level, and may be compositional (referring to the variety of elements in the system), structural (referring to the organization or pattern of the system), or functional (referring to ecological processes)" (http://science.nature.nps.gov/im/monitor/glossary.htm). Biotic integrity narrows the term biodiversity by explicitly calling for the conservation of only the composition (e.g., species), forms, and processes native to an area (Angermeier and Karr 1994), making it more closely aligned with NPS policies.

The Network believes that biotic integrity and natural conditions are good baselines by which to measure the health of the parks. The Network will emphasize the monitoring of composition and form since these components have been severely degraded, may continue to be degraded, and/or are valuable to park management. For example, all parks have lost species (i.e., composition) and may continue to lose species in the future. (Contrast that to other Networks such as the Central Alaska Network where species lost negligible and monitoring will focus on ecological processes.) Likewise, seral stage of grasslands and forest (i.e., form) is important to many of the parks as well as to regional biodiversity. This is not to say that monitoring of ecological functions and processes will not be conducted, but rather, it may be done less so than other Networks or monitoring programs.

Table 8 is a simple narrative model that shows the various measures of biological diversity. Although most definitions and discussions of biological diversity utilize various scales within an ecosystem, for illustrative purposes the model below emphasizes the biological diversity associated with a single organism, the bison. In theory, all of the elements in the model could be monitored. And similar models and monitoring could theoretically be done for all organisms. However, such an approach is infeasible because of the complexity of life found in natural systems. Yet an effective biodiversity monitoring program can be designed by tracking a subset or organisms or communities at various organizational levels and multiple spatial scales (Noss 1990).

Table 8. Components of Biological Diversity Using Bison as an Example

	Genetic	Species	Community
Composition	All organisms are comprised of unique genetic material, specifically, unique alleles and genes. **The number and type of alleles or genes is a measure of genetic composition.** The number and type of alleles or genes in bison could be monitored. In bison, an especially important issue in monitoring genetic composition would be the detection of non-bison alleles (such as cattle alleles) or rare bison alleles in a herd.	Natural systems are typically comprised of many different species. **The number of species present is a measure of the species composition of an area.** The presence of bison adds to the species richness of a system. The number of bison present would be a measure of the bison composition of a site.	**The number of different habitats or communities across a landscape is a measure of community diversity.** In terms of bison management, effective management and monitoring would track not only bison composition, form, and function, but also the composition of the entire ungulate community, i.e., the relative abundance or species evenness within the community.
Form (Structure)[1]	**The organization and pattern of genetic material is a measure of the structural diversity.** Such diversity can have management implications. For example, it's important to know if the genetic diversity of a bison herd is spread across the entire herd, or concentrated in only a few animals.	**The organization and pattern of species is the structural diversity.** Every individual and population is present in a certain form or structure. For example, the form of an individual bison can be measured by its age, sex, weight, and other measures. These elements are generally easily monitored. The form of a bison population can be measured by the number of subherds.	**Habitats and communities can be present in various forms.** Bison can directly and dramatically affect the structure of ecological communities. For example, bison grazing can convert a late seral stage grassland to an early stage and alter soil characteristics. A measurement of plant community and soil characteristics would provide information on vegetation as well as inferences about bison impacts.
Function (Process)[1]	**Various physiological and ecological processes, such as mutation, recombination, and selection, control the composition and form of genetic material and represent the functional diversity.** In bison the rate and direction of change in genetic material could be exacerbated by management practices (e.g., herd size, sex and age ratios, range management, culling strategies).	**The ecological processes associated with a species represent the functional diversity of a species.** Within species behaviors and processes occur that affect the viability of a species. For example, bison breed in the summer and give birth the following spring. Deviations from the natural variation in these processes could be indicative of stressors on bison behavior. Survivorship, recruitment, and emigration and immigration are critical processes that often need to be tracked by management.	**Energy, nutrients, chemicals, and other elements flow through a system representing community processes.** The numerous species and their form and abundances interact with other species and their ecosystems. How species interact ultimately affects the health and viability of the community. Bison are keystone species in grassland communities. Their grazing levels, movement patterns, nutrient cycling, and decomposition are all processes that could be monitored.

[1] *Form* and *structure* are often used interchangeably to describe the shape, pattern, and juxtaposition of a resource. *Function* and *process* are often used interchangeably to describe the dynamics and relationships of resources.

NUTRIENT MODEL

As a general statement, nutrient availability in the Northern Great Plains tends to be low compared to other ecosystems, with the lowest concentrations in the more western part of the region. This is primarily due to the hot dry climate. However, nutrient availability varies both spatially and temporally due to the variable weather (primarily precipitation and temperature) and the dynamic nature of the other ecological drivers in the system such as fire and short duration intensive grazing. As a general statement, nutrient pathways mediated by herbivores and fire are rapid whereas other pathways (e.g., litterfall) are slower. Yet there are exceptions to the pattern. For example, chronic heavy grazing and trampling can stress plants and slow and reduce nutrient transport within plants. Grazing and fire patterns across the landscape create a heterogeneous landscape of varying nutrient levels and transport rates, which result in differing feedbacks and controls, further adding diversity to the system. The amount of soil nutrients can directly influence plant composition and abundance at a site. Under some conditions nitrogen and carbon levels can be surprisingly high due to the complex feedback mechanisms between fire, grazing, and plants. Seastedt (1995) concluded that the current accumulation of nutrients in prairie soils can best be explained by a history of infrequent grazing and infrequent fires. The following model is revised from McNaughton et al. (1988).

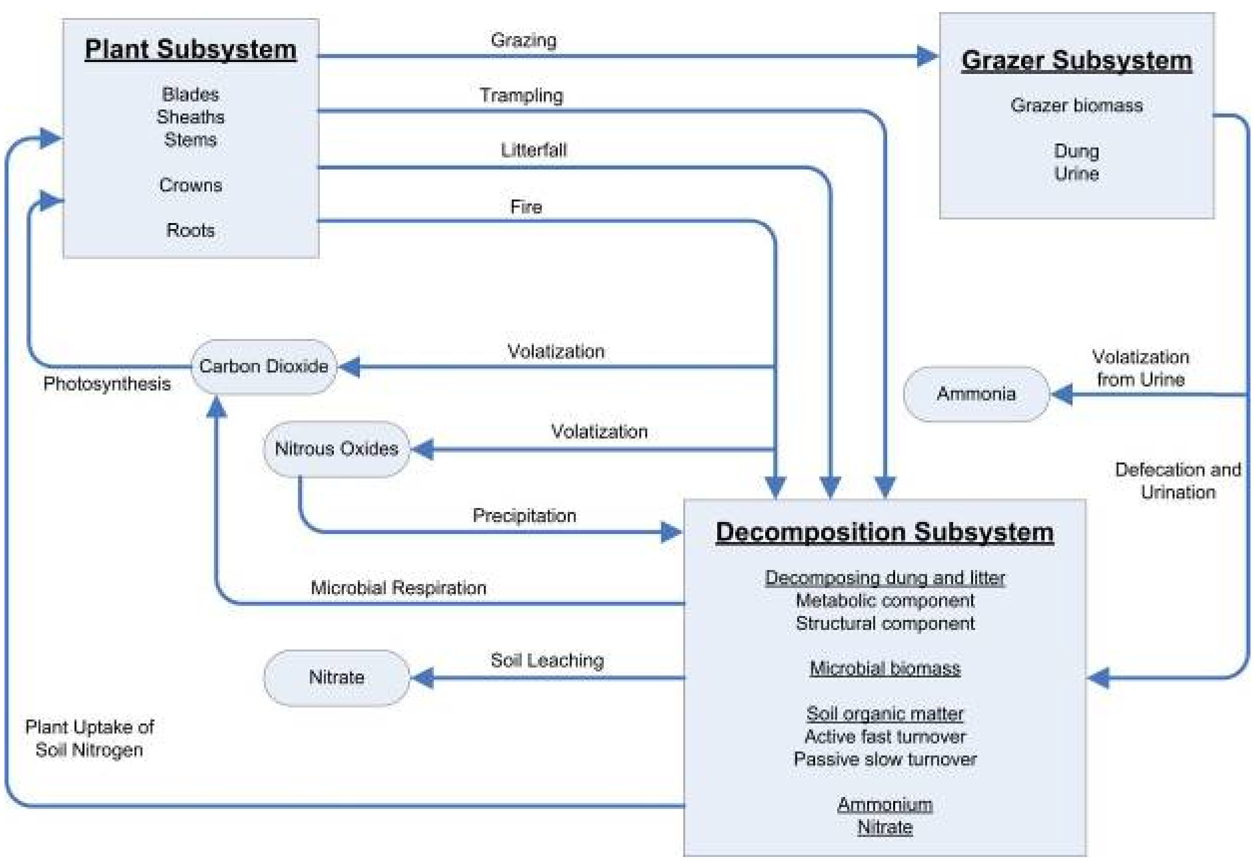

Figure 28. Grassland Nutrient Model

BISON AND OTHER WILDLIFE RELATIONSHIPS MODEL

According to NPS policies, all of the park ecosystems in the Network are degraded since all are missing native organisms. However, the impacts of the missing species often go beyond the species per se with direct implications on management. When a species is missing, or their demographics or functions severely altered from natural conditions, there is often a ripple effect throughout a system. The absence of some species may have a disproportionately large effect on a system.

The Northern Great Plains I&M Network developed a bison-centric model to facilitate Vital Signs planning (Figure 28). Bison were selected as the focal point of the model because 1) they play a significant role in grassland ecology and are a keystone species, 2) they are currently present and a significant management issue in three Network parks, 3) their absence affects ecosystem functioning in the other parks, and 4) they are a symbol of the region and the Network. Similar models could be developed for many other plant and wildlife resources. For purposes of simplification and clarity the model mostly omits direct effects on vegetation (however, see the other models) and focuses on bison interactions, directly and indirectly, with other grassland vertebrates.

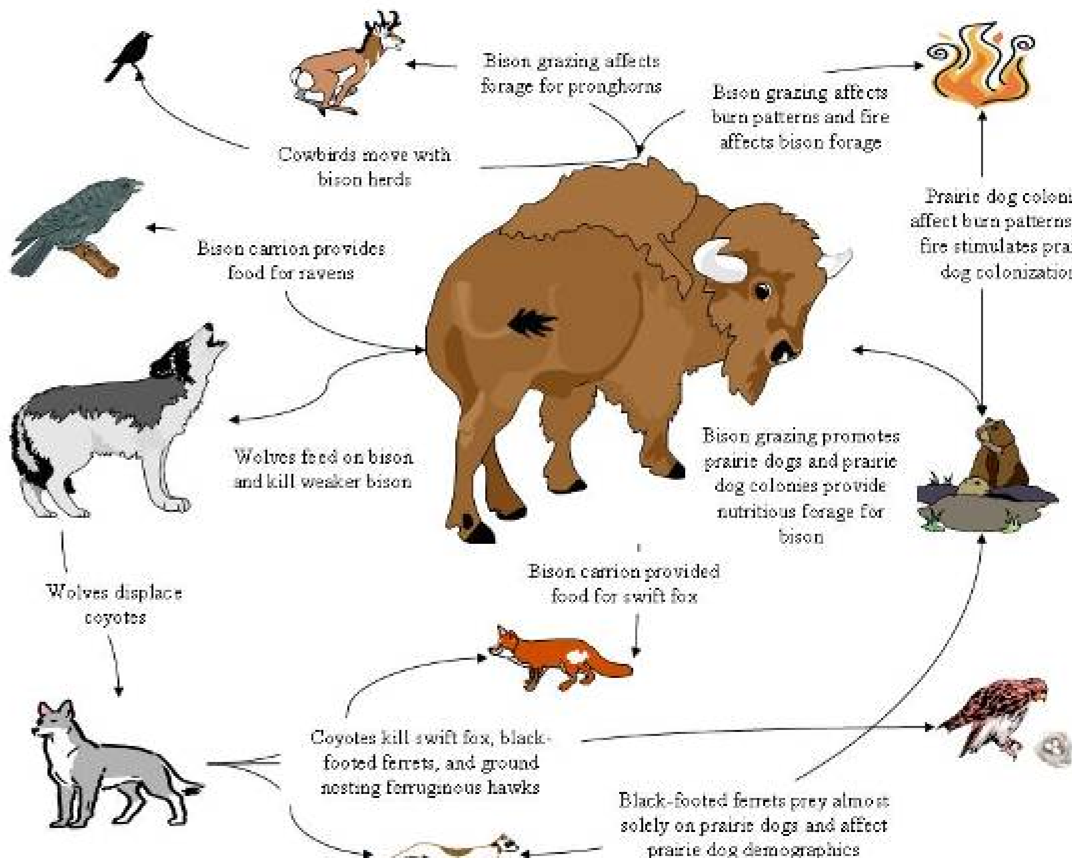

Figure 29. Bison and Other Wildlife Relationships Model

At the time of European settlement bison were the largest herbivore on the Great Plains and the gray wolf was the largest carnivore. Lewis and Clark reported on the great herds of bison and their “shepherds” the wolves. Wolf densities may have been higher on the Great Plains than anywhere else on earth (Licht 1997*b*). Predator-prey studies and theory strongly suggest that wolf predation of bison almost certainly took a disproportionate number of less fit, young, and old animals. Therefore wolves affected bison genetics, demographics, and perhaps, other bison functions. Conversely, bison were the primary food for Great Plains’ wolves and are the primary reason for the incredible density of wolves that likely occurred in the region at the time of European settlement.

But the story and model doesn't end there. It is well documented that wolves displace coyotes so one would assume that coyotes were rare or non-existent in the Northern Great Plains at the time of European settlement. The records of early explorers support this. Under the protective umbrella of the large wolves, and in the absence of the mid-size coyote, small carnivores such as the black-footed ferret, swift fox, and ground-nesting ferruginous hawk prospered. They prospered in part because wolves, even at the high densities that occurred in the historic Great Plains, were less dense than modern coyote populations so they less frequently came across ferrets, swift fox, and ground-nesting ferruginous hawks. Furthermore, wolves probably had little interest in these species for food, nor were they well adapted to catching them. And in the case of the swift fox, the size disparity between wolves and the small fox is so great that there was probably little inter-specific competition. However, with the extirpation of the wolf from the Great Plains the coyote flourished as the top predator. In contrast to the wolf, the coyote is a severe mortality factor on ferrets, ground-nesting ferruginous hawks, and the swift fox. In the latter case much of the mortality appears to be due to inter-specific competition between the swift fox and the slightly larger coyote.

The ripple effect of the absence of bison doesn't stop there. The incredible biomass of bison on the Great Plains, and the high densities of wolves, resulted in enormous amounts of carrion and nutrient cycling. In contrast, under current ranching operations, and even in National Park units and other protected areas, carrion is a missing resource and process in the Great Plains. The NPS units with bison all live-ship surplus animals to areas outside the park. So throughout the entire Great Plains the cycling of nutrients and minerals through bison has essentially stopped. This may affect soil quality and hence, have ripple effects up through trophic levels. The loss of carrion can also have a more direct effect. Ravens were historically the common corvid on the Great Plains and likely had a complex and dependent relationship with wolves and bison. It is probably not coincidental that when wolves and bison were extirpated the raven also disappeared, although there was no deliberate effort to eradicate the species from the region (like there was for the others). Similarly, the swift fox is a scavenger that likely benefited from bison carrion. This is probably especially true in the Northern Great Plains where other forage for the fox was rare or absent during severe winters with extended snow cover. It has been suggested that the loss of carrion may explain the disappearance of swift fox from the Northern Great Plains whereas they persisted in the Southern Great Plains.

Cowbirds also have a close historical relationship with bison; however, in the case of cowbirds it was more the ecological processes created by bison that benefited cowbirds than it was as a source of carrion. Cowbirds would accompany the vast herds of bison across the region, often perched on the backs of bison. As the bison moved they flushed insects that are prey for cowbirds. The bison would also flush ground-nesting songbirds. The cowbirds would then parasitize the nest by leaving an egg, before continuing on with the herds. It was a very efficient evolutionary strategy in the dynamic and mostly treeless Great Plains. However, the replacement of nomadic bison by sedentary cattle, and the increase in other food sources (e.g., small grains) and vertical structure (e.g., trees), has created ideal conditions for cowbirds to the detriment of many grassland passerines.

Another species that may be viewed as a keystone species, and has a very close mutualistic relationship with bison, is the black-tailed prairie dog. Heavy grazing by bison creates the short floral structure that is ideal for prairie dog colonization. Conversely, the burrowing, nutrient cycling, feeding, and other activities of prairie dogs create improved forage for bison, both in terms of nutritive value and plant phenology. Prairie dog colonies also positively affect many other species such as the black-footed ferret, swift fox, and ferruginous hawk by providing increased shelter, forage, and visibility.

Bison grazing, along with other grazing by other species, directly affects fire patterns, another ecological driver in grasslands. Fire has a complex and profound effect on grassland flora and fauna that extends well beyond the ability of any single conceptual model to fully capture. Fire effects are more fully described in some of the other models.

This simple model of vertebrate relationships is only one small part of the infinite and complex ecological relationships of grassland ecosystems. Even this bison-centric model doesn't address bison processes such as nutrient cycling through grazing, trampling, and waste products, the creation of micro-heterogeneity in the landscape via wallowing and trampling, seed dispersal via long distance movements, and seed germination through trampling. Nevertheless, the bison-centric model is valuable because it is illustrative, heuristic, and representative of the complexity of the system.

PLANT COMMUNITY RESPONSE MODEL

The North American prairie is a dynamic ecosystem. Dramatic and rapid changes can occur as the result of extreme dry or wet periods, severe winters, summer hailstorms, tornados, thunderstorms, fire, and heavy short-duration grazing by bison and locusts. In modern times some of these disturbances have been attenuated or eliminated (e.g., locusts, fire, short intensive bison grazing); however, new disturbances have occurred (e.g., infestations by exotic plants, cultivation). The extent that the ecological drivers in the region can affect plant communities is well documented in the classic works by Weaver (1943), Albertson and Weaver (1945, 1946), and Albertson et al. (1957) following the Dust Bowl of the 1930s. These studies and others have clearly shown that a particular site can transition from being dominated by tall warm-season grasses to mid-height cool-season grasses to short warm-season grasses and even to woody vegetation. The studies also illustrate the importance of collecting ancillary data (e.g., weather, grazing levels) to make sound inferences and conclusions about trends in vegetation communities.

Ecological drivers create landscape-level heterogeneity within a prairie biome. The feedback mechanisms and interactions between the drivers of weather, soil, fire, and grazing, are strong and complex. Figure 30 is a conceptual model of the effect these drivers have on plant community composition. For purposes of simplicity and comprehension the model applies only to the Northwestern Great Plains region as delineated by Omernik (1987), i.e., it does not apply to the more eastern tallgrass region and the Sandhills region of Nebraska. The purpose of the model is to show how the ecological drivers in the region change plant communities spatially and temporally.

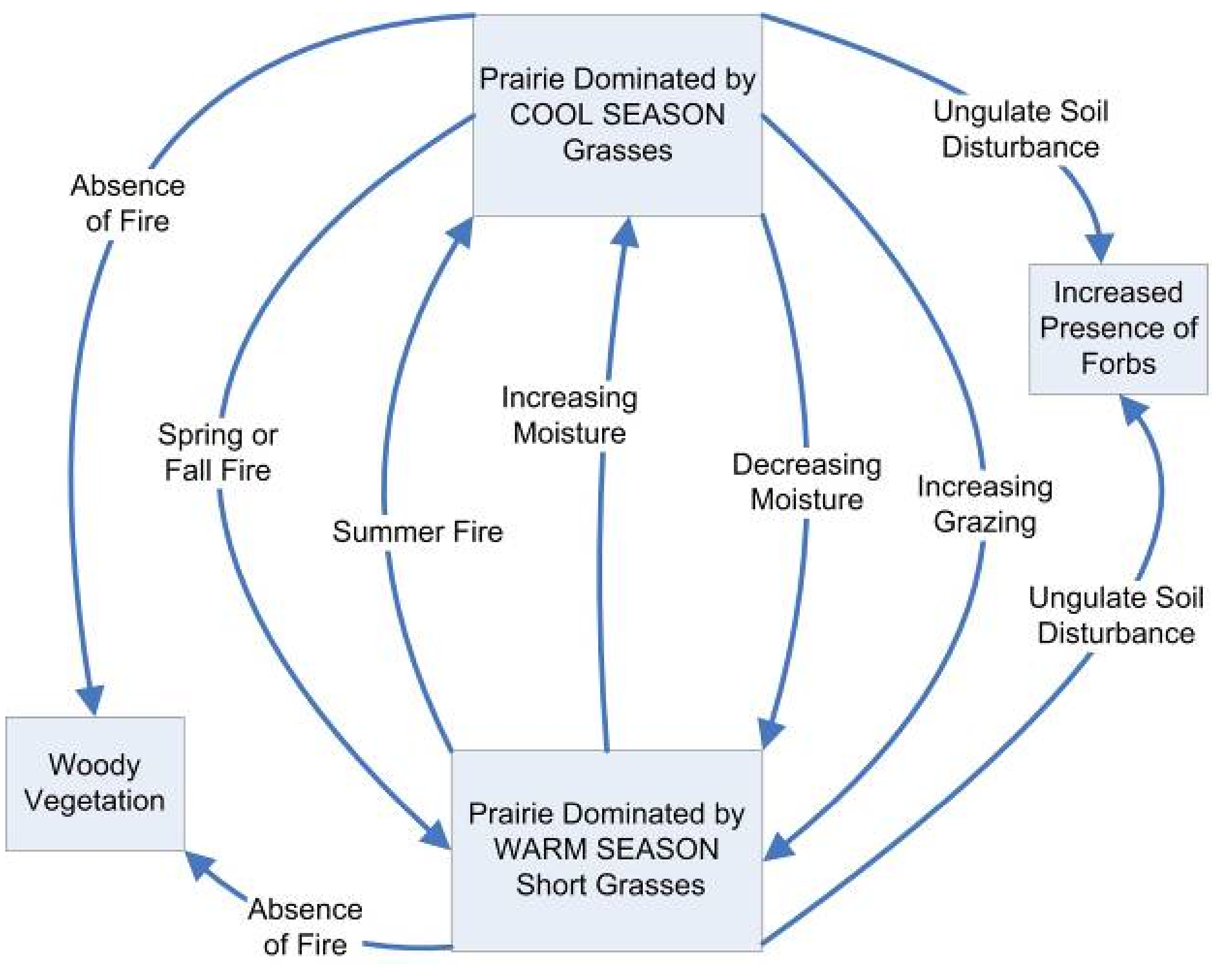

Figure 30. Plant Community Response Model

LAND USE CHANGE MODEL

The National I&M Program defines an ecosystem as "a spatially explicit unit of the Earth that includes all of the organisms, along with all components of the abiotic environment within its boundaries" (from Likens 1992). One could argue that the boundaries of the 13 parks within the Network delineate the extent of 13 discrete ecosystems. However, park resources and the processes that influence them extend well beyond park borders. The extent that outside influences have on resources within the park varies by resource and issue. For example, the ecosystem for a nematode may essentially consist of one acre of native prairie within a park boundary, whereas the ecosystem for riverine fish may consist of the entire watershed, and the ecosystem for air quality may encompass the entire Northern Great Plains. Figure 31 is a straightforward model of the stressors on park ecosystems. The model depicts a hypothetical park. Not all parks are experiencing all stressors, nor are all parks experiencing the same degree of ecosystem impacts. A discussion of the various stressors follows. The order of the stressors is in accordance with their general severity on parks in the Network.

<u>Fragmentation</u> – Although the impacts of fragmentation have been known since the early days of wildlife management, only in recent years have scientists fully understood the extent and the implications of the stressor (Saunders et al. 1991, Turner et al. 2001). Indeed, fragmentation could be viewed as an anthropogenic driver because its impacts are manifested in numerous and profound ways. At a regional level, the fragmentation of the Great Plains has had numerous harmful impacts on the region's biological diversity (Licht 1997*a*, Engle et al. 2003). The effects of fragmentation are especially severe when adjoining land use differs dramatically from the protected area. For example, nest predation and parasitism of grassland birds are higher near a grassland/woodland edge than they are away from the edge (Winter et al. 2000, Burger et al. 1994). Similar impacts occur when the grassland edge abuts cultivated fields or residential areas. Saunders et al. (1991:2) stated that small fragmented tracts of habitat are often "predominantly driven by factors arising in the surrounding landscape." In the case of small prairie parks, the remnant tract may look like grassland, but many of its ecological processes may be driven by the adjacent habitat. Fragmentation also disrupts movement patterns that were often critical to the life history of grassland species. Without connectivity between habitat patches many species cannot survive stochastic and catastrophic events. All parks in the Network suffer from this stressor, although to varying degrees. The stressor is especially severe at small parks located in a dramatically altered landscape, such as Fort Laramie NHS, Fort Union Trading Post NHS, Knife River Indian Villages NHS, the Missouri NRR, and Scotts Bluff NM.

<u>Small Size of Parks</u> – Although fragmentation and the small size of parks are typically inseparable factors, there are impacts and stresses on a system that are more strongly associated with area, regardless of adjoining land uses. The loss of species from small habitats is reflected in the well documented species-area relationship of island-biogeography, which states that the number of species found in a habitat island is a function of its area, i.e. the larger the island the more species it can support (MacArthur and Wilson 1967). This relationship is most readily apparent with large mammals such as wolves, bears, and mountain lions that simply need large areas to meet their biological needs. However, it is also relevant on much smaller tracts. For example, many grassland birds are area-dependent during the breeding season and simply won't breed without adequate area. Samson and Knopf (1982) found that in the tallgrass region only relict prairies larger than 395 acres were able to maintain stable bird communities and that the annual number of prairie bird species was more strongly correlated with area than it was with habitat heterogeneity, edge, or isolation. Herkert (1994) found that the savanna, grasshopper, and Henslow's sparrow, bobolink, and eastern meadowlark required minimum areas ranging from 12-136 acres for breeding purposes. Generally speaking, about two-thirds of all grassland bird species appear to be area-dependant during the breeding season; in contrast, many alien bird species that are increasing to pest-like proportions in the Great Plains are area-independent (e.g., starling, common grackle, house sparrow). In some cases a small site may not have all the resources a species needs to survive such as water, shelter, or breeding areas. Although management could theoretically create the habitat diversity and features needed, this creates a dilemma because it would have to be at a tradeoff of smaller habitat patches which theoretically makes the site unsuitable for area-dependent species. Even when a site is large enough to support a species, it may not be large enough to maintain genetic variability or natural behaviors and processes. For example, inbreeding and a lack of genetic variability is a concern for bison, bighorn sheep, and black-footed ferrets in Network parks. Another problem with small park size is that it reduces the ecological redundancy that was characteristic of the pre-Columbian Great Plains. Without redundancy in habitats there may be no refugia for species to persist through catastrophic events (e.g., fire). Many grassland species historically survived catastrophic events by re-colonizing disturbed sites, but such refugia may not be present on

small sites. For example, prescribed fires ostensibly set for prairie management that did not leave nearby unburned areas have likely extirpated butterflies from many small prairie tracts (Swengel 1996). Without redundancy there is little margin for error in terms of management action. All parks in the Network suffer from their small size, but the impact is especially severe at eight of the parks (see Table 1). The stress is exacerbated at many parks, including large units such as Badlands NP, by the linear and irregular shape of the parks which decreases the area to perimeter ratio.

Exotic Plants – Nationwide, exotic plants rank as the greatest threat to the ecology of our National Parks (Hester 1991). The impacts of exotics are manifold. Most noticeable is that they can completely displace native flora. This is especially likely to happen in disturbed areas because most plants native to the Great Plains are not good colonizers. The change in vegetation community has a ripple effect throughout the system. Every park in the Network suffers severely from this stressor. Notable exotic plants in the Northern Great Plains include crested wheatgrass, purple loosestrife, spotted knapweed, leafy spurge, Canada thistle, sweetclover, several species of brome grass, Russian olive, and wormwood.

Dams – The great majority of rivers and streams in the Northern Great Plains now have dams on them. Even tiny ephemeral drainages are often dammed for purposes of livestock. The largest river in the region, the Missouri, is one of the most dammed and altered rivers in the country. Approximately 36% of the river has been inundated by reservoirs, 40% has been channelized, and the remaining 24% has been altered and degraded by the patterns of water releases from the six major dams on the river (U.S. Fish and Wildlife Service 1993). The impacts of dams on a riverine system are severe, complex, and wide ranging, so much so that the stressor could be considered an anthropogenic driver. The impacts include changes in sediment transport, geomorphologic processes, water levels, flow rates, groundwater hydrology, water temperature, oxygen levels, fish movement, floodplain composition and structure, and many others. Dams are a severe stressor of park resources at Fort Laramie NHS, Fort Union Trading Post NHS, Knife River Indian Villages NHS, the Missouri NRR, the Niobrara NSR, and Scotts Bluff NM.

Missing Species – The complex and profound effects of species missing from an ecosystem were illustrated in previous models. The absence of species is both an effect and cause of ecosystem disruption and degradation. The absence of keystone species (also known as “ecosystem engineers”) such as bison, wolves, and prairie dogs can have especially profound ramifications on ecosystem processes. The absence of large predators, in combination with other stressors, has led to overabundance of ungulates such as deer, elk, and bison in several parks. Every park in the Network suffers from this stressor.

Fire Suppression – Since fire is an ecological driver in the Great Plains it is reasonable to assume that the absence or misapplication of fire can have severe consequences, and that is indeed the case. Fire suppression, especially in the tallgrass and mixed-grass region and in the Black Hills, has led to encroachment of woody species affecting the composition and form of grassland ecosystems. Misapplication of fire may stress a system as well. For example, prairie fires in the presence of grazers such as bison typically burn in a patchy pattern. Such pattern leaves refugia for small invertebrates and provides landscape heterogeneity. In contrast, fires in the absence of grazing can reduce landscape diversity and even extirpate species.

Grazing – The absence of both fire and grazing can have severe consequences for grasslands. However, whereas fire is absent from many areas, the estimated tens of millions of bison on the Western Plains were replaced by an estimated 45 million cows and an equal number of domestic sheep in 1890 (Fedkiw 1989). Although cattle can replicate some elements of bison grazing, they differ in many other respects. For example, cattle tend to spend more time in riparian areas whereas bison range more widely over the landscape. Perhaps more significantly than the substitution of cattle for bison per se, is that management of cattle for maximum sustained yield of meat production has created a homogeneous landscape by removing the grazing variability historically created by bison. For example, the uniformity of grazing management on the Great Plains probably has a more negative effect on endemic avian assemblages than the actual presence of cattle (Knopf 1996). Current grazing levels and practices are known as “managing for the middle” because they almost uniformly result in a middle seral stage at the cost of early and late stages.

Water Pollution – Water pollution can take many forms including physical, chemical, and biotic. Physical pollution can occur as the result of land use practices such as logging that increase sedimentation into streams and rivers. Chemical pollution can take a variety of forms, including point pollution and non-point pollution, of pesticides, industrial waste, and atmospheric deposition. Biotic pollution includes fecal material and other organic inputs. This is a common concern in the Northern Great Plains because much of the landscape is used for livestock. Nutrient loading ultimately favors eutrophic species and can dramatically change community composition. Selenium is a natural mineral that is released by irrigation practices; elevated levels of the element have been found in addled piping plover and least tern eggs in Nebraska (Fannin and Esmoil 1993) and South Dakota(Ruelle 1993).

<u>Prior Land Use</u> – Restoring previously disturbed areas can be very difficult. For example, formerly cultivated areas have a degraded soil structure with the various horizons homogenized into a uniform strata. In many cases they may have significantly reduced levels of organic matter. Formerly cultivated and disturbed areas are prone to invasion by exotic plants, so the stressor works in combination with others. Parks with significant acreages of formerly cultivated areas include Fort Laramie NHS, Fort Union Trading Post NHS, Knife River Indian Villages NHS, Missouri NRR, and Scotts Bluff NM.

<u>Exotic and Feral Animals</u> – Whereas exotic plants rank as the greatest threat to the ecology of our National Parks, exotic animals were the fourth most commonly reported problem (Hester 1991). Feral animals including dogs and cats are widely recognized as having severe impacts on some wildlife resources. The impact of feral animals is closely correlated with nearby human population density. Many exotics, such as house sparrows, house mice, and starlings are also strongly associated with human presence. Plague is an exotic to North America that can affect both people and wildlife. However, the impacts of introduced animals also includes species native to North America, but alien to the park and region. For example, raccoons, opossums, and crows have all greatly expanded their range due to anthropogenic changes to the landscape. These species can have severe impacts on species native to a site such as grassland nesting birds. Likewise, bird communities have changed due to anthropogenic changes on the landscape. Knopf (1986) found that virtually 90% of the 82 breeding bird species in the shortgrass region of eastern Colorado were not present in 1900. Introduced fish species are also a widely recognized threat to ecosystem integrity; however, in the case of fish much of the movement was a deliberate effort to alter an ecosystem.

<u>Pesticides</u> – Perhaps more than 200 million pounds of pesticides are applied annually in the Great Plains (Licht 1997*a*). The impacts of herbicides, insecticides, fungicides, and other pesticides on wildlife are well documented in the scientific and popular literature. Pesticide impacts in parks may be the result of park control efforts (e.g., herbicides for controlling exotic plants) or from external applications.

<u>Air Pollution</u> – The Great Plains has typically been known for its clear and clean air. However, that may change in the future. Air pollution may increase in Network parks due to energy development in portions of Wyoming and Montana. Increased pollution has many observable effects, but it also includes less direct impacts. For example, increased levels of atmospheric nitrogen associated with air pollution may threaten the stability of tallgrass prairie remnants (Wedin and Tilman 1992).

<u>Roads</u> – Roads have many obvious impacts on a park ecosystem, such as noise disturbance and mortality. Mortality can be especially high for scavengers such as swift fox and species that may find ideal perches (utility poles) near the roads and prey on the road (e.g., loggerhead shrikes feeding on grasshoppers). Roads can also have less observable effects. For example, they can also serve as barriers to some species. A study in Kansas grassland found that very few prairie voles and cotton rats crossed a dirt track that was only 10 feet wide (Swihart and Slade 1984).

<u>Visitor Impacts</u> – Visitors to park units can directly impact park resources. For example, trampling of vegetation and compaction of soils is a concern at several parks (e.g., on the Tower at Devils Tower NM). Trail erosion due to hikers is an impact at other parks (e.g., Mt. Rushmore NMEM). Some wildlife species, including many raptors, large ungulates, and carnivores, are sensitive to human disturbance and will avoid areas with high human presence. Human impacts can also be indirect. For example, picnickers on Missouri and Niobrara River sandbars leave food remains which attract predators such as magpies and common crows, resulting in reduced nest success of rare sandbar-nesting birds such as the piping plover (Licht and Johnson 1992). Visitor impacts occur at all parks although the severity of the impact often differs greatly within parks.

<u>Climate Change</u> – Anthropogenic climate change could significantly affect weather patterns in the Great Plains, one of the ecosystem drivers. A warmer and more arid Great Plains due to climate warming could paradoxically result in a shift to more C_3 (i.e., cool season) plants because these plants can better exploit what little moisture is available in the spring before the severe water deficits of summer (Clark et al. 2002). However, other analysis suggests a

change to more C_4 plants (Collins and Glenn 1995). Climate change may affect not only the means, but the variability in weather patterns, perhaps resulting in longer drought cycles. A modeling study of climate change on Wind Cave NP found that global warming could increase grassland vegetation and decrease forested and shrubby vegetation (Bachelet 2000).

Groundwater and Irrigation Withdrawals – Groundwater and surface water withdrawals for irrigation, livestock, and domestic use threaten not only the aquatic ecosystems within the grassland biome, but also Great Plains society. Luckey et al. (1988) predicted that at the current rate of water depletion parts of the plains could face extreme water shortages by the year 2020, resulting in dire economic and social consequences. Groundwater and irrigation withdrawals affect all Network parks, although the degree of the impact does not appear severe in most cases.

Infrastructure – Buildings, maintenance areas, and other infrastructure are for park operations. This infrastructure directly eliminates natural resources and habitat, and may lead to increases in fragmentation and other stressors. The amount of infrastructure in Network parks ranges from about 7% of the land cover to less than 1%. The percentage of land cover in administrative areas is generally inversely correlated with the total acreage of the parks.

Miscellaneous– Several other stressors affect park resources to varying degrees. Noise disturbance from aerial overflights and other activities has the potential to disrupt wildlife behavior, as well as visitor experiences. Structures and development outside a park can also affect visitor experiences. The impacts become especially dramatic in the park units that are comparatively more pristine and not yet affected by viewshed impacts.

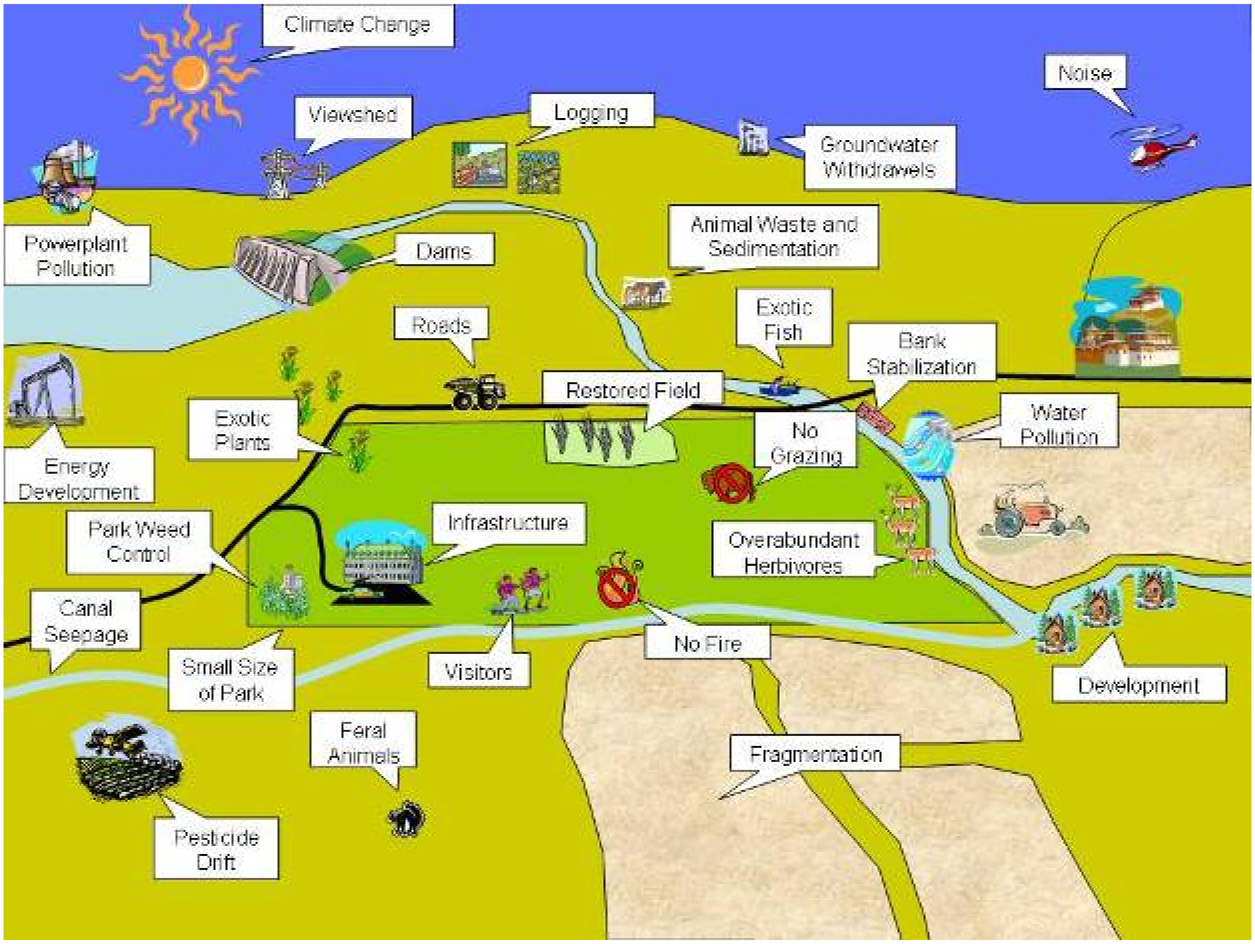

Figure 31. Anthropogenic Stressors on Great Plains Parks

TERRESTRIAL ECOSYSTEM MODEL

A terrestrial ecosystem model was developed that identified significant drivers and terrestrial resources, and the anthropogenic stressors that disrupted these processes, features, and structures. The model shows the most significant controls and feedbacks. The model was designed for terrestrial prairie ecosystems, but was found to work satisfactorily for forest systems as well. Since the stressors are discussed in detail in the preceding model, and the resources are discussed throughout this plan, they are not discussed further here. The following discussion elaborates on the most significant drivers in the Great Plains. The drivers are discussed in no particular order, indeed, it is probably unwise to try and rank their significance because they all interact to create and maintain the Great Plains ecosystem.

<u>Weather</u> - The Northern Great Plains is characterized by extremes in weather ranging from hot dry summers to cold winters with prolonged snow cover. High winds often compound the effects of temperature and precipitation, and have numerous less subtle but equally important effects on the ecosystem (e.g., pollen and seed dispersal). Annual variation is often great, with drought cycles returning every decade or so. Borchert (1950) summarized the common climatic attributes of North American prairie as 1) low winter snow and rainfall, 2) high probabilities of large rainfall deficits in summer (as it relates to primary production), 3) fewer days of rainfall compared to nearby forested areas, 4) low summer cloud cover, 5) low summer relative humidity, 6) large departures from average temperature, 7) frequent hot, dry winds in summer; and 8) frequent departures from average climatic conditions. The variable climate is a driving influence on the composition, structure, and processes of prairie ecosystems, and directly affects the influence of other drivers on the ecosystem. Although droughts are typically viewed as a negative impact on grasslands, that is a commodity or economic perspective. From an ecological viewpoint droughts are a primary force in maintaining grassland communities. The variable weather in the Northern Great Plains can confound analyses of changes in the ecosystem and the causative factors of those changes. To overcome this ecosystem monitoring should be accompanied by local weather data.

<u>Fire</u> - Fire is critical to creating and maintaining temperate grasslands. It's been suggested that without fire most grasslands would succeed to forest or shrubland. North American prairie fires historically occurred in all months of the year, but fuel conditions and weather patterns lead to peak fire frequencies in July/August and a secondary peak in the spring (Bragg 1982). Indians frequently ignited fires to drive or attract game. In the comparatively humid tallgrass region fires may have historically occurred every 3-10 years. In mixed-grass prairies fires were probably a more regular occurrence, sometimes striking in both the spring and fall at the same site (Bragg 1982). In the shortgrass regions fires occurred less frequently (due to a lighter fuel load), perhaps only every 15-30 years (Wendtland and Dodd 1992). The effect of fire is variable. For example, in mixed-grass prairies both dormant-season and growing-season burns generally decrease total plant production in that year, while in tallgrass prairie, mid- to late-spring burning generally increases overall productivity (Bragg 1995). Fire results in substantial losses of nitrogen through volatilization, with perhaps twice as much nitrogen lost in a single fire as enters the system yearly in rainfall or by nitrogen-fixing organisms (Seastedt 1988, Ojima et al. 1990, Hobbs et al. 1991). The removal of vegetation and plant surface litter also results in an exposed soil surface that is typically warmer and drier than that of unburned prairie. With enhanced plant growth, available nitrogen is locked away in plant tissue, while higher photosynthetic rates place strong demands on soil water. Plants respond to nitrogen and water limitations by allocating more photosynthate to roots. This input of new roots to prairie soil is critical to the accumulation of soil organic matter and humus (Seastedt 1995). The subsequent improvement in forage following a fire attracts bison and other ungulates. Conversely, grazing patterns affect the patchiness and intensity of fires, and both interact with climate, the other driver of grassland ecosystems (Anderson 1982).

<u>Biotic Interactions</u> - There are many biotic interactions in a grassland ecosystem. One that is especially pronounced in such systems is the process of grazing (Milchunas et al. 1988). Grasslands generally support large numbers of herbivores, including large concentrations of nomadic ungulates that are ecological drivers (Detling 1988, Licht 1997*a*). Worldwide, large mammalian herbivores (including livestock) remove, on average, 30 to 40% of the aboveground net primary production in grasslands, while insects remove another 5 to 15%. Belowground invertebrate consumers, primarily nematodes, consume another 6 to 40% of the belowground net primary production. The plant species composition of grassland can change in response to herbivory. As a general statement, Northern Great Plains species such as big bluestem, little bluestem, and Indian grass decrease under

regimes of prolonged grazing while species such as blue grama, side-oats grama, and buffalograss increase. However, the impacts of herbivory can differ from one site to the next and also interact with fire and climate. Ungulate grazers increase nitrogen cycling in grasslands and are likely to affect export rates as well (Blair et al. 1998). Chronic heavy-grazing by ungulates may result in a loss of root mass, as plants respond to herbivory by using root reserves to produce new foliage, rather than sending photosynthate to the root system to find new sources of N and water. In the western portions of the prairie, this system may prevail, with the dominant species well adapted to grazing. Infrequent grazing may function similarly to infrequent fire, causing a transient pulse of productivity in response to increased availability of nitrogen, water and light. Landscape heterogeneity due to grazing (and fire) is an important characteristic of grassland ecosystems, and responsible for much of the biological diversity. Monitoring of beta (i.e., among site) diversity can be an important measure of the health and diversity of grasslands. Whereas heavy and prolonged grazing may be detrimental to many plants (i.e., the *decreasers*) and animals (e.g., many butterflies, game birds) within grassland landscapes, others benefit. For example, in portions of the Northern Great Plains prairie dogs, swift fox, ferruginous hawks, and mountain plovers all benefit from heavy grazing by ungulates. From an ecological perspective the terms *over-grazing* and *under-grazing* are only useful when referring to particular elements or processes of the grassland ecosystem, and are not used in the prairie model.

Soil Type – Soil is the result of complex and long interactions between climate, fire, hydrology, bedrock, and biota. Since prairie soils are often nitrogen limited it stands that the flora composition and vigor at a site is in part a response to soil nitrogen levels (as well as the other ecological drivers of weather, biotic interactions, hydrology, fire, and landform). Other soil characteristics such as physical composition and form, moisture levels, biota, and chemical composition also influence the primary productivity at a site. The physical characteristics of soil can also directly affect animals such as prairie dogs, a species that is known as an ecosystem engineer and one that has direct feedbacks on soil characteristics. Prairie dogs need soils that can maintain and support their burrowing. Large areas of the Great Plains such as the Nebraska Sandhills are void of prairie dogs because the sandy soils do not support burrowing. Seastedt (1995) called prairie soils "overachievers" because of the surprisingly high amounts of stored carbon and nitrogen.

Hydrology - The hydrology of any particular site in the Northern Great Plains is closely tied to precipitation; however, in some cases it may be precipitation that occurred either in a far away place (e.g., rivers) or time (e.g., groundwater). Great Plains hydrology is widely recognized as a limiting factor for both wildlife and people (see Longo and Yoskowitz 2002). Water stresses the Great Plains ecosystem not only because of its scarceness, but also because of its variability both temporally and spatially. This variability (in terms of availability) is generally more pronounced away from the Black Hills and Rocky Mountains. Many species adapt to this variability by senescence, movement, torpor, or other means. Conversely, anthropogenically increased levels of water can jeopardize grassland ecosystem integrity by allowing invasion of species that may outcompete native species. The stressors on grassland hydrology are discussed in detail in the aquatic resources model later in this section.

Landform - In some respects landform may be the least significant of the ecological drivers since the Great Plains is often a flat area with little topographic relief. However, in another sense landform could be considered the driver among drivers. The Rocky Mountains is the primary reason the Northern Great Plains are dry and the location in the middle of the North American continent is the reason the region experiences a temperate climate. Yet even at a much smaller scale landform can and does affect park resources and processes. For example, Theodore Roosevelt NP has a rugged and diverse topography. North facing slopes often support solid stands of juniper whereas south facing slopes may be mostly barren. The presence of bighorn sheep at Theodore Roosevelt and Badlands NPs is a direct consequence of the landforms present.

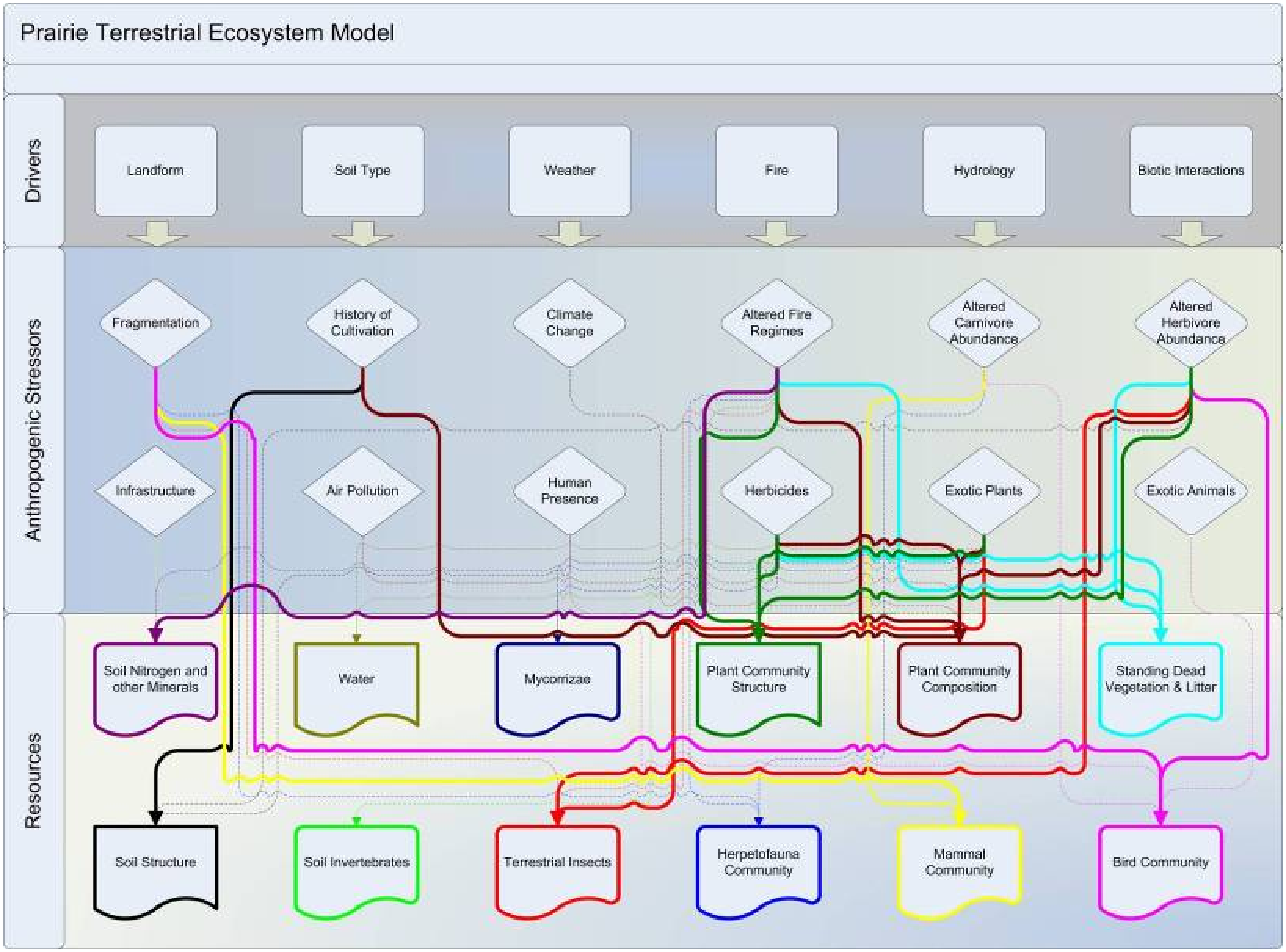

Figure 32. Terrestrial Ecosystem Model

AQUATIC ECOSYSTEM MODEL

A control model was developed for aquatic systems in the Northern Great Plains I&M Network. The model focuses primarily on rivers, streams, and groundwater because wetlands and other standing waters are extremely rare in Network parks. The only other significant surface water is sewage ponds (Badlands NP, Jewel Cave NM, Wind Cave NP) and small impoundments and tanks for large ungulates (Badlands and Theodore Roosevelt NPs). The sewage ponds are typically closed systems. The impoundments and tanks for ungulates are generally an anthropogenic feature within a low-order stream. The aquatic control model explicitly included natural drivers and anthropogenic stressors to the system as well as the aquatic resources they affect. These drivers and stressors are discussed in detail in some of the previous models and will only be briefly discussed in this section.

Prairie streams and rivers are characterized by variable flow regimes (Matthews 1988, Dodds et al. 1996). In low-order prairie streams surface water is often ephemeral and intermittent for any particular reach. Low-order streams typically alternate between high flows in spring and early summer to intermittent flows to dry conditions during late summer and winter. Prairie rivers often have wide fluctuations in surface area with extensive exposed sand and mud flats in the summer and fall. Scouring floods may interrupt stream and river flow at any time, but are most prevalent in association with spring and summer storms (Gray et al. 1998). The natural hydrograph of the Missouri River differs from most other streams in the region in that it typically has two regular peaks; an early spring rise (from snowmelt in the prairie combined with rainfall) and a late spring rise (from snowmelt from mountain snowpacks: Hesse and Sheets 1983).

Many first- and second-order streams in prairies occur in areas devoid of trees. The lack of vegetative inputs (i.e., leaves and woody debris), combined with frequent and prolonged dry periods and periodic scouring floods, allow for very little in-stream decomposition (Matthews 1988). Therefore, entire groups of stream detritivores are missing from prairie streams. The organisms present are adapted to the extreme variability in prairie stream ecosystems. They tend to have stress-resistant life stages, short generation times, rapid growth, rapid colonization potential, or combinations of these traits (Matthews 1988, Gray and Dodds 1998). The high exposure of prairie streams to sunlight results in within-stream primary production being a major source of organic matter; however, such production may be limited by organic carbon (Gray and Dodds 1998). In contrast, allochthonous inputs, especially leaf litter, predominate in the few forested streams in the Network and in-stream primary production is low. Macro-invertebrate communities can be a good indicator of aquatic nutrient pathways as well as many other variables.

There are numerous stressors on aquatic resources including grazing ungulates, fire, logging, dams, residential development, pollution, exotic species, water withdrawals, and cultivation. Only a few of these, such as large ungulates (i.e., bison) and fire, originate within parks. Recreational use is an especially significant stressor on aquatic resources at the Missouri NRR and the Niobrara NSR.

There are essentially an infinite number of measures that could be taken to monitor the ecological integrity of prairie rivers and streams. However, they generally fall into four broad categories. They are (adapted from Karr and Dudley 1981):

- Flow Regime – Measures include average flow, extremes, and other measures of temporal and spatial variability. Measurements can take the form of unit area per time (e.g., cubic feet per second), river depth, and width. USGS and other entities often use automated devices to record these measurements.
- Water Quality – Measurements include dissolved oxygen, temperature, sediment loads, nutrients, and toxics. The NPS Water Resources Division has developed four core water quality measurements that need to be included as part of any water quality monitoring program. Many state agencies and the U.S. Environmental Protection Agency take these measurements and store the data in the STORET database.
- Habitat Structure – Measurements include substrate composition and form, woody debris, percent canopy cover, and other physical measurements.
- Energy Relationships – Measurements include primary productivity, allochthonous inputs, and organic material.

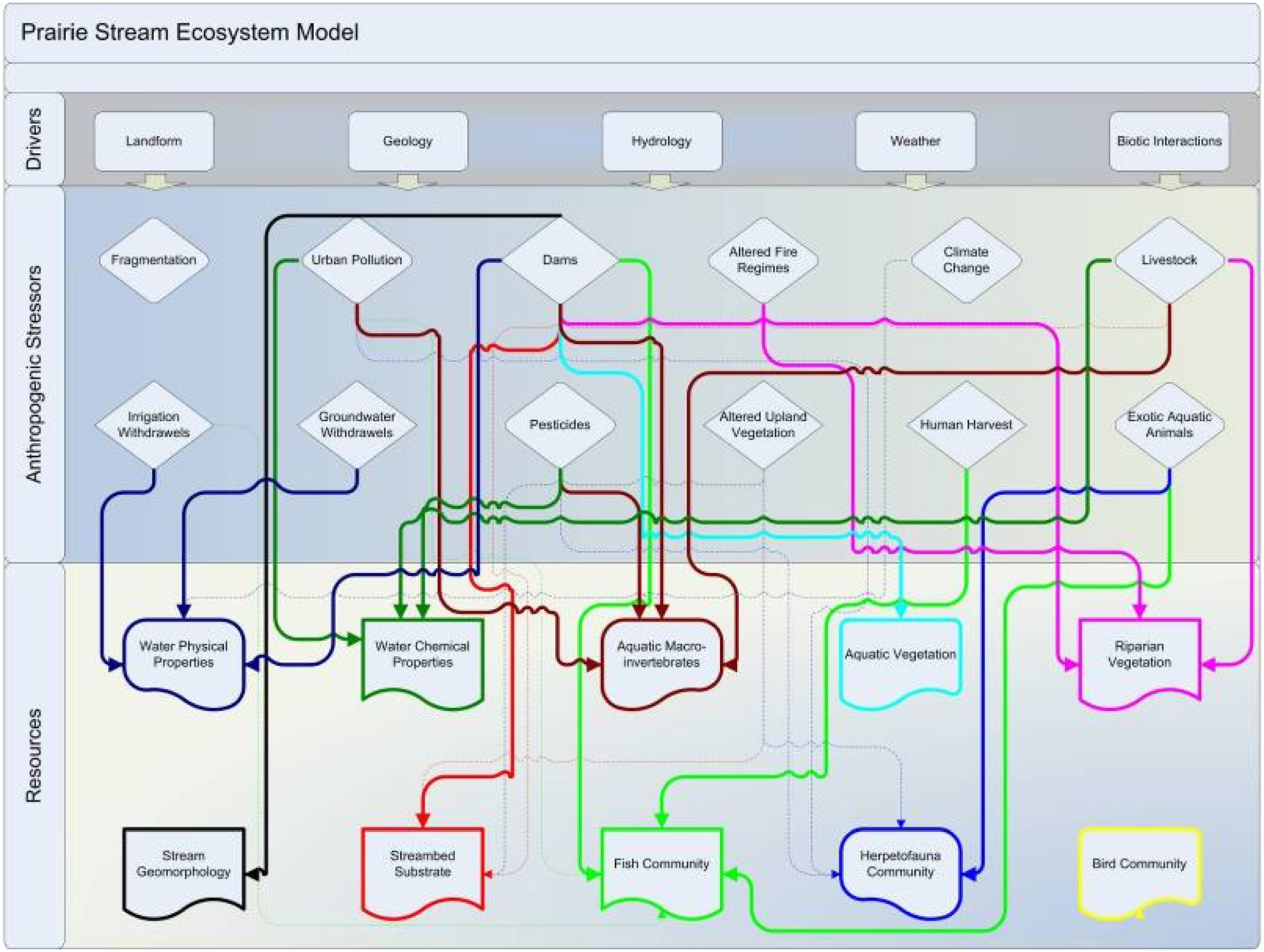

Figure 33. Prairie Stream Ecosystem Model

CHAPTER 3. PRIORITIZATION AND SELECTION OF VITAL SIGNS

CHAPTER 4. SAMPLING DESIGN

CHAPTER 5. SAMPLING PROTOCOLS

CHAPTER 6. DATA MANAGEMENT

CHAPTER 7. DATA ANALYSIS AND REPORTING

CHAPTER 8. ADMINISTRATION/IMPLEMENTATION OF MONITORING PROGRAM

CHAPTER 9. SCHEDULE

CHAPTER 10. BUDGET

CHAPTER 11. LITERATURE CITED

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APPENDIX A: GLOSSARY AND ACRONYMS

GLOSSARY

Biological diversity—Also known as biodiversity, it is most simply described as the variety of life, although numerous definitions exist. Biodiversity is often defined as having three components (composition, form, function) and three hierarchical levels (genetic, species, community).

Biotic Integrity—A term which narrows the term biodiversity by explicitly calling for the conservation of only the composition (e.g., species), forms, and processes native to an area, making it more closely aligned with NPS policies.

Driver—The driving forces that exert a large-scale control on the system. Drivers used in the Northern Great Plains I&M Network models are natural in origin (this definition contrasts with some other definitions which include anthropogenic drivers). Examples are fire, weather, biotic interactions, hydrology, and landforms.

Ecological Integrity—A concept that expresses the degree to which the physical, chemical, and biological components (including composition, structure, and process) of an ecosystem and their relationships are present, functioning, and capable of self-renewal.

Ecosystem Driver—see Driver.

Ecosystem—A spatially explicit unit of the Earth that includes all of the organisms, along with all components of the abiotic environment within its boundaries.

Indicator—A subset of monitoring attributes that are particularly information-rich in the sense that their values are somehow indicative of the quality, health, or integrity of the larger ecological system to which they belong. Indicators are a selected subset of the physical, chemical, and biological elements and processes of natural systems that are selected to represent the overall health or condition of the system.

Inventory—A one-time or infrequent assessment or documentation of the resources and processes present at a site. May or may not be systematic in approach.

Monitor—The collection and analysis of repeated observations or measurements to evaluate changes in condition and progress toward meeting a management objective (Elzinga et al. 1998). Detection of a change or trend may trigger a management action, or it may generate a new line of inquiry. Monitoring is often done by sampling the same sites over time, and these sites may be a subset of the sites sampled for the initial inventory.

Stressor—The perturbations to a system that are (a) foreign to that system and/or (b) natural to the system but applied at an unnatural level due directly or indirectly to anthropogenic actions. Examples of anthropogenic stressors include water withdrawal, pesticide use, emissions from energy development, and the extirpation of top-level predators and ungulates. The NGPN made a conscious effort to clearly differentiate anthropogenic stressors from natural stressors due to the confusion sometimes caused by the word stressor when it is not qualified.

Vital Signs—As used by the National Park Service, Vital Signs are a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values. The elements and processes that are monitored are a subset of the total suite of natural resources that park managers are directed to preserve "unimpaired for future generations," including water, air, geological resources, plants and animals, and the various ecological, biological, and physical processes that act on those resources. Vital signs may occur at any level of organization including landscape, community, population, or genetic level, and may be compositional (referring to the variety of elements in the system), structural (referring to the organization or pattern of the system), or functional (referring to ecological processes).

ACRONYMS

303(d)	Section 303(d) of the Clean Water Act
AGFO	Agate Fossil Beds National Monument
BADL	Badlands National Park
BLM	Bureau of Land Management
CCC	Civilian Conservation Corps
CE	Categorical Exclusion
CESU	Cooperative Ecosystems Studies Unit
Corp	U.S. Army Corp of Engineers
DETO	Devils Tower National Monument
EA	Environmental Assessment
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FIA	Forest Inventory Analysis
FOLA	Fort Laramie National Historic Site
FONSI	Finding of No Significant Impact
FOUS	Fort Union Trading Post National Historic Site
FWS	U.S. Fish and Wildlife Service
FY	Fiscal Year
GIS	Geographic Information System
GMP	General Management Plan
GPS	Global Positioning System
I&M	Inventory and Monitoring
IMPROVE	Interagency Monitoring of Protected Visual Environments
JECA	Jewel Cave National Monument
KNRI	Knife River Indian Villages National Historic Site
MNRR	Missouri National Recreational River
MOA	Memorandum of Agreement
MORU	Mount Rushmore National Memorial
NADP	National Atmospheric Deposition Program
NEPA	National Environmental Policy Act
NGP	Northern Great Plains
NHS	National Historic Site
NIOB	Niobrara National Scenic River
NM	National Monument
NMEM	National Memorial
NP	National Park
NPS	National Park Service
NVCS	National Vegetation Classification System
NWR	National Wildife Refuge
RAWS	Remote Automated Weather Station
RMP	Resource Management Plan
ROD	Record of Decision
SCBL	Scotts Bluff National Monument
TACS	Time/area Constrained Searches
THRO	Theodore Roosevelt National Park
USGS	United States Geological Survey
VCP	Variable Circular Plots
WASO	Washington Office, National Park Service
WICA	Wind Cave National Park

APPENDIX B: SUMMARY OF RELEVANT LAWS, POLICIES, AND GUIDANCE

PUBLIC LAWS	SIGNIFICANCE TO INVENTORY AND MONITORING
National Park Service Organic Act (16 USC 1 et seq. [1988], Aug. 25, 1916).	The 1916 National Park Service Organic Act is the core of park service authority and the definitive statement of the purposes of the parks and of the National Park Service mission. The act establishes the purpose of national parks: To conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.
General Authorities Act of 1970 (16 USC 1a-1?1a-8 (1988), 84 Stat. 825, Pub. L. 91-383	The General Authorities Act amends the Organic Act to unite individual parks into the "National Park System." The act states that areas of the National Park System, "though distinct in character, are united through their inter-related purposes and resources into one national park system as cumulative expressions of a single national heritage; that individually and collectively, these areas derive increased national dignity and recognition of their superb environmental quality through their inclusion jointly with each other in one national park system preserved and managed for the benefit and inspiration of all the people of the United States."
Redwood National Park Act (16 USC 79a-79q (1988), 82 Stat. 931, Pub. L. 90-545	This act includes both park-specific and system-wide provisions. This act reasserts system-wide protection standards for the National Park System. This act qualifies the provision that park protection and management "shall not be exercised in derogation of the values and purposes for which these areas have been established" by adding "except as may have been or shall be directed and specifically provided for by Congress." Thus, specific provisions in a park's enabling legislation allow park managers to permit activities such as hunting and grazing.
National Environmental Policy Act of 1969 (42 USC 4321-4370)	The purposes of NEPA include encouraging harmony between [humans] and their environment and promote efforts which will prevent or eliminate damage to the environment and stimulate the health and welfare of [humanity]. NEPA requires a systematic analysis of major federal actions that includes a consideration of all reasonable alternatives as well as an analysis of short-term and long-term, irretrievable, irreversible, and unavoidable impacts. Within NEPA the environment includes natural, historical, cultural, and human dimensions. Within the NPS emphasis is on minimizing negative impacts and preventing 'impairment' of park resources as described and interpreted in the NPS Organic Act. The results of evaluations conducted under NEPA are presented to the public, federal agencies, and public officials in document format (e.g. EAs and EISs) for consideration prior to taking official action or making official decisions.
Clean Water Act (33 USC 1251-1376)	The Clean Water Act, passed in 1972 as amendments to the Federal Water Pollution Control Act, and significantly amended in 1977 and 1987, was designed to restore and maintain the integrity of the nation's water. It furthers the objectives of restoring and maintaining the chemical, physical and biological integrity of the nation's waters and of eliminating the discharge of pollutants into navigable waters by 1985. Establishes effluent limitation for new and existing industrial discharge into U.S. waters. Authorizes states to substitute their own water quality management plans developed under S208 of the act for federal controls. Provides an enforcement procedure for water pollution abatement. Requires conformance to permit required under S404 for actions that may result in discharge of dredged or fill material into a tributary to, wetland, or associated water source for a navigable river.
Clean Air Act (42 USC 7401-7671q, as amended in 1990)	Establishes a nationwide program for the prevention and control of air pollution and establishes National Ambient Air Quality Standards. Under the Prevention of Significant Deterioration provisions, the act requires federal officials responsible for the management of Class I Areas (national parks and wilderness areas) to protect the air quality related values of each

	area and to consult with permitting authorities regarding possible adverse impacts from new or modified emitting facilities.? The act establishes specific programs that provide special protection for air resources and air quality related values associated with NPS units. The EPA has been charged with implementing this act.
Endangered Species Act of 1973, as amended (ESA) (16 USC 1531-1544)	The purposes of the ESA include providing "a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved." According to the ESA "all federal departments and agencies shall seek to conserve endangered species and threatened species" and each federal agency shall insure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered species or threatened species. The USFWS (non-marine species) and the National Marine Fisheries Service (NMFS) (marine species, including anadromous fish and marine mammals) administers the ESA. The effects of any agency action that may affect endangered, threatened, or proposed species must be evaluated in consultation with either the USFWS or NMFS, as appropriate.
Environmental Quality Improvement Act of 1970 (42 U.S.C. 56 ? 4371)	Directs all Federal agencies, whose activities may affect the environment, to implement policies established under existing law to protect the environment.
National Historic Preservation Act of 1966, as amended (16 USC 470 et seq.)	Congressional policy set forth in NHPA includes preserving "the historical and cultural foundations of the Nation" and preserving irreplaceable examples important to our national heritage to maintain "cultural, educational, aesthetic, inspirational, economic, and energy benefits." NHPA also established the National Register of Historic Places composed of districts, sites, buildings, structures, and objects significant in American history, architecture, archeology, engineering, and culture. NHPA requires federal agencies take into account the effects of their actions on properties eligible for or included in the National Register of Historic Places and to coordinate such actions with the State Historic Preservation Offices (SHPO).
Wilderness Act of 1964 (16 USC 1131 et seq.)	Establishes the National Wilderness Preservation System. In this act, wilderness is defined by its lack of noticeable human modification or presence; it is a place where the landscape is affected primarily by the forces of nature and where humans are visitors who do not remain. Wilderness Areas are designated by Congress and are composed of existing federal lands that have retained a wilderness character and meet the criteria found in the act. Federal officials are required to manage Wilderness Areas in a manner conducive to retention of their wilderness character and must consider the effect upon wilderness attributes from management activities on adjacent lands.
Forest and Rangeland Renewable Resources Planning Act of 1974 (16 U.S.C. 36 ? 1642	Mandates that the Secretary of Agriculture inventory and monitor renewable natural resources in National Forests, and has been cited as congressional authorization for the inventory and monitoring of natural resources on all federal lands.? While this is not specifically directed in the act it is perhaps indicative of a national will to account for and manage the nation's natural heritage in manner that sustains these resources in perpetuity.
Surface Mining Control and Reclamation Act	The Surface Mining Control and Reclamation Act was enacted in 1977. It establishes a nationwide program to protect the environment from adverse effects of surface coal mining operations, establishes minimum national standards for regulating surface coal mining, assists states in developing and implementing regulatory programs, and promotes reclamation of previously mined areas with inadequate reclamation. Under the Act, the Secretary of the Interior is directed to regulate the conduct of surface coal mining throughout the United States for both federally and non-federally owned rights. The Act establishes the Abandoned Mine Reclamation Fund, which is for the reclamation of land and water affected by coal mining. Eligibility for reclamation under this program requires that the land or water had been mined for coal, or affected by coal mining, and had been inadequately reclaimed prior to the enactment of this act in 1977. Both public and private lands are eligible for funding. Sections 522(e)(1) and 533(e)(3) of the act specifically prohibit surface mining within the National Park Service, National Wildlife Refuge System, National System of Trails, National Wilderness Preservation System, or Wild and Scenic Rivers System. The act also prohibits surface mining that adversely impacts any publicly-owned park or place

	included in the National Register of Historic Sites. These prohibitions are subject to valid existing rights at the time of the Act, the exact definition of which remains the subject of administrative and legal action. How valid existing rights are ultimately defined will affect the ability of mineral owners to mine in the Recreation Area.
Federal Advisory Committee Act	Creates a formal process for federal agencies to seek advice and assistance from citizens. Any council, panel, conference, task force or similar group used by federal officials to obtain consensus advice or recommendations on issues or policies fall under the purview of FACA.
National Parks Omnibus Management Act, 1998 (P.L. 105-391)	Requires Secretary of Interior to continually improve NPS' ability to provide state-of-the-art management, protection, and interpretation of and research on NPS resources. Secretary shall assure the full and proper utilization of the results of scientific study for park management decisions. In each case where an NPS action may cause a significant adverse effect on a park resource, the administrative record shall reflect the manner in which unit resource studies have been considered. The trend in NPS resource conditions shall be a significant factor in superintendent's annual performance evaluations. Section 5939 states that the purpose of this legislation is to: (1) More effectively achieve the mission of the National Park Service; (2) Enhance management and protection of national park resources by providing clear authority and direction for the conduct of scientific study in the National Park System and to use the information gathered for management purposes; (3) Ensure appropriate documentation of resource conditions in the National Park System; (4) Encourage others to use the National Park System for study to the benefit of park management as well as broader scientific value, and (5) Encourage the publication and dissemination of information derived from studies in the National Park System.
Government Performance and Results Act (GPRA)	Requires the NPS to set goals (strategic and annual performance plans) and report results (annual performance reports). The NPS Strategic Plan contains four GPRA goal categories: park resources, park visitors, external partnership programs, and organizational effectiveness. In 1997, the NPS published its first GPRA-style strategic plan, focused on measurable outcomes or quantifiable results.
EXECUTIVE ORDERS	
Off-Road Vehicle Use (Executive Orders 11644 and 11989)	Executive Order 11644, enacted February 8, 1972 and amended by Executive Order 11989 on May 24, 1977, regulates off-road vehicle use. If the enabling legislation allows the use of off-road vehicles, NPS is required to designate specific areas for off-road vehicle use. These areas must be "located to minimize damage to soil, watershed, vegetation, or other resources" (Section (3)(a)(1)). If it is determined that such use is adverse to resources, the NPS is to immediately close such areas or trails until the impacts have been corrected.
Floodplain Management (Executive Order 11988)	Executive Order 11988 was enacted May 24, 1977. It requires all federal agencies to "reduce the risk of flood loss,... minimize the impacts of floods on human safety, health and welfare, and ... restore and preserve the natural and beneficial values served by flood plains." To the extent possible, park facilities, such as campgrounds and rest areas, should be located outside floodplain areas. Executive Order 11988 is implemented in the National Park Service through the *Floodplain Management Guidelines* (National Park Service, 1993b). It is the policy of the National Park Service to 1) restore and preserve natural floodplain values; 2) to the extent possible, avoid environmental impacts to the floodplain by discouraging floodplain development; 3) minimize the risks to life and property when structures and facilities must be located on a floodplain; and, 4) encourage nonstructural over structural methods of flood hazard mitigation.
Protection of Wetlands (Executive Order 11990)	Executive Order 11990 was enacted May 24, 1977. It requires all federal agencies to "minimize the destruction, loss, or degradation of wetlands, and preserve and enhance the natural and beneficial values of wetlands." Unless no practical alternative exists, federal agencies must avoid any activities that have the potential to adversely affect wetland ecosystem

	integrity. NPS guidance pertaining to this Executive Order is stated in *Floodplain and Wetland Protection Guidelines* (National Park Service, 1980).
Executive Order 13112 on Invasive Species	This executive order was signed into law on February 3, 1999, to prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause. Among other things, this Executive Order established the National Invasive Species Council and required the preparation of a National Invasive Species Management Plan to recommend specific, performance-oriented goals and objectives and specific measures of success for Federal agency efforts concerning invasive species.
NPS POLICIES AND GUIDANCE	
NPS Management Policies 2001 (NPS Directives System)	This is the basic NPS servicewide policy document. It is the highest of three levels of guidance documents in the NPS Directives System. The Directives System is designed to provide NPS management and staff with clear and continuously updated information on NPS policy and required and/or recommended actions, as well as any other information that will help them manage parks and programs effectively.
NPS Directors Orders	Second level of NPS Directives System. Directors Orders serve a vehicle to clarify or supplement *Management Policies* to meet the needs of NPS managers. Relevant Directors Orders: DO-2.1 Resource Management Planning DO-12 Environmental Impact Assessment DO-14 Resource Damage Assessment & Restoration DO-24 Museum Collections Management DO-41 Wilderness Preservation & Management DO-47 Sound Preservation & Noise Management DO-77 Natural Resource Protection
NPS Handbooks and Reference Manuals	This is the third tier in the NPS Directives System. These documents are issued by Associate Directors. These documents provide NPS field employees with a compilation of legal references, operating policies, standards, procedures, general information, recommendations and examples to assist them in carrying out *Management Policies* and Director's Orders. Level 3 documents may not impose any new servicewide requirements unless the Director has specifically authorized them to do so. Relevant Handbooks and Reference Manuals: NPS-75 Natural Resources Inventory & Monitoring NPS-77 Natural Resources Management Guidelines NPS Guide to Fed. Advisory Committee Act

APPENDIX C: SCIENTIFIC NAMES OF SPECIES IN TEXT

PLANTS

absinth wormwood	*Artemisia absinthium*
alfalfa	*Medicago sativa*
American elm	*Ulmus americana*
ash	*Fraxinus spp.*
aspen	*Populus tremuloides*
beaked hazel	*Corylus cornuta*
big bluestem	*Andropogon gerardii*
blue grama	*Bouteloua gracilis*
boxelder	*Acer negundo*
buffalograss	*Buchloe dactyloides*
bur oak	*Quercus macrocarpa*
Canada thistle	*Cirsium arvense*
chokecherry	*Prunus virginiana*
cottonwood	*Populus deltoides*
crested wheatgrass	*Agropyron cristatum*
double twinpod	*Physaria brassicoides*
elm	*Ulmus spp.*
flowering-straw	*Stephanomeria runcinata*
green ash	*Fraxinus pennsylvanica*
green needlegrass	*Nassella viridula*
houndstongue	*Cynoglossum officinale*
Indian grass	*Sorghastrum nutans*
Kentucky bluegrass	*Poa pratensis*
leafy spurge	*Euphorbia esula*
little bluestem	*Schizachyrium scoparium*
matted prickly gilia	*Leptodactylon caespitosum*
mountain mahogany	*Cercocarpus montanus*
narrow-leaf milkvetch	*Astragalus pectinatus*
needle-and-thread grass	*Hesperostipa comata*
nodding buckwheat	*Eriogonum cernuum*
Nuttall desert-parsley	*Lomatium nuttallii*
paper birch	*Betula papyrifera*
Parry's rabbitbrush	*Ericameria parryi*
peach-leaved willow	*Salix amygdaloides*
ponderosa pine	*Pinus ponderosa*
prairie coneflower	*Ratibida spp.*
prairie sandreed	*Calamovilfa longifolia*
prickly lettuce	*Lactuca serriola*
Rocky Mountain juniper	*Juniperus scopulorum*
sedge	*Carex spp.*
side-oats grama	*Bouteloua curtipendula*
silver sagebrush	*Artemisia cana*
smooth brome	*Bromus inermis*
spearhead phacelia	*Phacelia hastata*
Spotted Knapweed	*Centaurea biebersteinii*
spotted mission bells	*Fritillaria atropurpurea*
stemless nailwort	*Paronychia sessiliflora*
stickseed	*Lappula cenchrusoides*
thread-leaved sedge	*Carex spp.*
Western snowberry	*Symphoricarpos occidentalis*
western wheatgrass	*Pascopyrum smithii*
whitestem stickleaf	*Mentzelia albicaulis*
willow	*Salix spp.*
yellow sweetclover	*Melilotus officinalis*

VERTEBRATES

badger	*Taxidea taxus*
bald eagle	*Haliaeetus leucocephalus*
beaver	*Castor canadensis*
big brown bat	*Eptesicus fuscus*
bighorn sheep	*Ovis canadensis*
bison	*Bison bison*
black-backed woodpecker	*Picoides arctus*
black-footed ferret	*Mustela nigripes*
black-tailed prairie dog	*Cynomys ludovicianus*
brown creeper	*Certhia americana*
Cassin's finch	*Carpodacus cassinii*
common poorwill	*Phelaenoptilus nuttallii*
coyote	*Canis latrans*
elk	*Cervus Canadensis*
fringed myotis	*Myotis thysanodes*
hoary bat	*Lasiurus cinereus*
least tern	*Sterna antillarum*
Lewis' woodpecker	*Melanerpes lewis*
long-legged myotis	*Myotis volans*
longnose sucker	*Catostomus catostomus*
mountain lion	*Felis concolor*
pallid sturgeon	*Scaphirhynchus albus*
Piping plover	*Charadrius melodus*
pronghorn	*Antilocapra americana*
rabbits	*Sylvilagus sp.*
raccoon	*Procyon lotor*
ring-necked pheasant	*Phasianus colchicus*
sharp-tailed grouse	*Tympanuchus phasianellus*
Shorthead redhorse	*Moxostoma macrolepidotum*
silver-haired bat	*Lasionycteris noctivagans*
smallmouth bass	*Micropterus dolomieu*
striped skunk	*Mephitis mephitis*
swift fox	*Vulpes velox*
Townsend's big-eared bat	*Plecotus townsendii*
Western small-footed bat	*Myotis leibii*
white sucker	*Catostomus commersoni*
white-tailed deer	*Odocoileus virginianus*
wild turkey	*Meleagris gallopavo*
wolves	*Canis lupus*

MISCELLANEOUS

tawny crescent butterfly	*Phyciodes batesii*

APPENDIX D: MONITORING AND REPLICABLE RESEARCH PROJECTS

Active Monitoring and Applicable Research Projects

PARK	PROJECT TITLE	CATEGORY	RESOURCE, I.E., VITAL SIGN	LEAD AGENCY	START	FREQUENCY
AGFO	NOAA Climate Reference Network Station	AIR	weather	Western Regional Climate Center	2004	
AGFO	NOAA RAWS Weather Monitoring	AIR	weather	Western Regional Climate Center		hourly
AGFO	Park Weather Monitoring	AIR	weather			daily
AGFO	LTEM Bird Monitoring	ANIMAL	bird community	LTEM		annually
AGFO	USGS Breeding Bird Survey Survey Route	ANIMAL	bird community	USGS-BRD		annually
AGFO	Park Incidental Snake Observations	ANIMAL	snake community	Park		
AGFO	State of Nebraska CWD Monitoring	ANIMAL	CWD prevalence	State of Nebraska		
AGFO	Park Incidental Wildlife Observations	ANIMAL	wildlife community	Park		
AGFO	Fire Effects Monitoring	PLANT	vascular plant community	Fire Effects		variable
AGFO	LTEM Vegetation Monitoring	PLANT	vascular plant community	LTEM		annually
AGFO	Park Thistle Control Project	PLANT	Canada thistle	Park		
AGFO	Park Monitoring of Number of Visitors	VISITOR	visitor use	Park		
AGFO	Park Well Water Monitoring	WATER	drinking water	Park		twice a month
AGFO	Pesticide Use	WATER	all aquatic resources	Park		
AGFO	EPA Storet Database Sampling Sites	WATER	water quality	EPA		
AGFO	LTEM Water Monitoring	WATER	water quality	LTEM		annually
AGFO	SDSU Water Quality Project	WATER	water quality	SDSU	2004	
AGFO	State of Nebraska Irrigation Monitoring	WATER	canal flow	State of Nebraska		
AGFO	State of Nebraska Monitoring of NPS Flow Guage	WATER	river flow	State of Nebraska	2004	
BADL	IMPROVE Air Quality Monitoring, continuous O3	AIR	air resources	NPS ARD, Park		
BADL	particulate, NO and SO monitoring	AIR	air resources	SD Dept. Env & NR	10/1/2004	
BADL	Visibility	AIR	air resources	NPS ARD, Park	1/13/1988	
BADL	NOAA RAWS Weather Monitoring	AIR	climate	Western Regional Climate Center under NOAA		
BADL	Weather and Ozone Monitoring	AIR	climate	Park	8/1/2003	
BADL	Weather Monitoring at White River	AIR	climate	Park		
BADL	Park Burrowing Owl Monitoring	ANIMAL	burrowing owl	Park	2001	annually
BADL	Park Christmas Bird Count	ANIMAL	bird community	USGS-BRD	2001	annually
BADL	USGS Breeding Bird Survey Routes	ANIMAL	bird community	USGS-BRD	2002	annually
BADL	Gypsy Moth Monitoring	ANIMAL	gypsy moth			
BADL	Park Butterfly Monitoring	ANIMAL	butterfly community	Park	2004	annually
BADL	Bighorn Sheep Monitoring	ANIMAL	bighorn sheep	Park	1996	annually
BADL	Bison Census	ANIMAL	bison	Park	2001	annually
BADL	Bison Roundup	ANIMAL	bison	Park	2002	annually
BADL	Black-footed Ferret Project	ANIMAL	black-footed ferret	Park		annually
BADL	Black-tailed Prairie Dog Monitoring	ANIMAL	black-tailed prairie dog	Park		annually
BADL	Deer Monitoring by Oglala Sioux Tribe	ANIMAL	deer	Oglala Sioux Parks and Rec.	1999	annually

BADL	Park Coyote Monitoring	ANIMAL	coyote	Park		annually
BADL	Pronghorn Monitoring by State of SD	ANIMAL	pronghorn	State of South Dakota		annually
BADL	Swift Fox Reintroduction	ANIMAL	swift fox	SDSU	2003	
BADL	Fire Effects Monitoring	PLANT	vascular plants	Fire Effects		variable
BADL	EPMT Exotic Plant Control	PLANT	exotic plants	EPMT, Park		annually
BADL	Canada Thistle Monitoring	PLANT	Canada thistle	EPMT, Park		
BADL	South Dakota Dept. of Ag Tamarisk Monitoring	PLANT	tamarisk	South Dakota Dept. of Agriculture		
BADL	Larson Sweet Clover Study	PLANT	sweet clover		2000	annually
BADL	Park Monitoring of Number of Visitors	VISITOR	visitor use	Park		
BADL	Pesticide Use	WATER	all aquatic resources	Park		
BADL	Well Water Monitoring	WATER	drinking water	Park		
BADL	EPA Storet Database Sampling Sites	WATER	water quality	EPA		
BADL	SDSU Water Quality Project	WATER	all aquatic resources	SDSU	2004	
BADL	USGS Water Gauge	WATER	river flow	USGS		
DETO	RAWS Weather Monitoring	AIR	environmental conditions	Western Regional Climate Center under NOAA		hourly
DETO	Park Prairie Falcon Monitoring	ANIMAL	praire falcon	Park		annually
DETO	Gypsy Moth Monitoring	ANIMAL	gypsy moth	U.S. Forest Service		
DETO	Park Black-tailed Prairie Dog Monitoring	ANIMAL	black-tailed prairie dog	Park		
DETO	Fire Effects Monitoring	PLANT	vascular plants	Fire Effects		variable
DETO	EPMT Photo Points	PLANT	vascular plants	EPMT		annually
DETO	EPMT Exotic Plant Control	PLANT	vascular plants	EPMT		annually
DETO	Park Mapping of Exotic Plants	PLANT	vascular plants	Park		
DETO	Flora Evaluation on Top of Tower	PLANT	vascular plants	Park		every 10 years
DETO	Soil Evaluation on Top of Tower	SOIL	soil	Park		every 10 years
DETO	Sound Study for New Airport	SOUND	natural sounds	FAA	2003	1-minute
DETO	Park Monitoring of Number of Visitors	VISITOR	visitor use	Park		
DETO	Pesticide Use	WATER	all aquatic resources	Park		annually
DETO	Well Water Monitoring	WATER	drinking water	Park		annually
DETO	SDSU Water Quality Project	WATER	all aquatic resources	SDSU	2004	
DETO	EPA Storet Database Sampling Sites	WATER	water quality	EPA		
DETO	Groundwater Levels	WATER	groundwater	Park	1996	monthly
DETO	Aircraft Overflight Monitoring	Sound/View	natural sounds/viewshed			
FOLA	Weather Monitoring	AIR		NOAA		daily
FOLA	Incidental Wildlife Observations	ANIMAL	wildlife community	Park		intermittent/daily
FOLA	Bird Observations	ANIMAL	bird community	private citizen	1988	intermittent/month
FOLA	EPMT Exotic Plant Control	PLANT	vascular plants	EPMT		annually
FOLA	Park Monitoring of Russian Olive	PLANT	Russian olive	Park		annually
FOLA	Park Monitoring of Salt Cedar	PLANT	salt cedar	Park		annually
FOLA	Park Monitoring of Number of Visitors	VISITOR	visitor use	Park		daily
FOLA	Pesticide Use	WATER	all aquatic resources	Park		annually
FOLA	Well Water Monitoring	WATER	drinking water	Park		every two weeks
FOLA	Grey Rocks Water Monitoring	WATER	river	USGS		annually

FOLA	SDSU Water Quality Project	WATER	all aquatic resources	SDSU	2004	
FOLA	EPA Storet Database Sampling Sites	WATER	water quality	EPA		
FOUS	Weather Monitoring	AIR		Park	1991	daily
FOUS	Sturgeon Study	ANIMAL	sturgeon	USFWS		
FOUS	Gypsy Moth Monitoring	ANIMAL	gypsy moth	Park		
FOUS	Fire Effects Monitoring	PLANT	vascular plants	Fire Effects		variable
FOUS	Park Monitoring of Number of Visitors	VISITOR	visitor use	Park		daily
FOUS	Pesticide Use	WATER	all aquatic resources	Park		
FOUS	Well Water Monitoring	WATER	drinking water	Park		
FOUS	EPA Storet Database Sampling Sites	WATER	water quality	EPA		
FOUS	SDSU Water Quality Project	WATER	all aquatic resources	SDSU	2004	
JECA	Cave Climate Monitoring	AIR	cave		1986	monthly
JECA	Weather	AIR	weather	NOAA	early 90s	daily
JECA	Christmas Bird Count	ANIMAL	bird community	USGS-BRD		
JECA	USGS Breeding Bird Survey Routes	ANIMAL	bird community	Park		
JECA	Gypsy Moth Monitoring	ANIMAL	gypsy moth	U.S. Forest Service		
JECA	Park Bat Monitoring	ANIMAL	bats	Park		annually
JECA	Photo Points in Cave	GEOLOGY	cave	Park		
JECA	Fire Effects Monitoring	PLANT	vascular plants	Fire Effects		variable
JECA	Butler Exotic Plant Study	PLANT	vascular plants	U.S. Forest Service	2003	
JECA	EPMT Exotic Plant Control	PLANT	vascular plants	EPMT		annually
JECA	Exotic Plant Inventory	PLANT	vascular plants	Park	2000	variable
JECA	Park Monitoring of Number of Visitors	VISITOR	visitor use	Park		
JECA	Pesticide Use	WATER	all aquatic resources	EPMT		
JECA	SDSU Herbicide Monitoring in Cave	WATER	groundwater	South Dakota State University	2003	variable
JECA	Well Water Monitoring	WATER	drinking water	Park		
JECA	SDSU Water Quality Project	WATER	all aquatic resources	SDSU	2004	
JECA	Cave water quality monitoring	WATER	springs and groundwater	Park	early 90s	monthly
KNRI	Weather	AIR				
KNRI	Corp of Engineers Tern and Plover Monitoring	ANIMAL	terns and plovers	Corp of Engineers		annually
KNRI	Gypsy Moth Monitoring	ANIMAL	gypsy moth	State of North Dakota	early 90s	
KNRI	Rick Inglis Bank Erosion Monitoring	GEOLOGY	river	Park		
KNRI	Fire Effects Monitoring	PLANT	vascular plants	Fire Effects		variable
KNRI	Skalsky Exotic Plant Mapping	PLANT	vascular plants	Park		
KNRI	Heartrot Disease Monitoring	PLANT	trees	Park		
KNRI	EPMT Exotic Plant Control	PLANT	vascular plants	EPMT		annually
KNRI	Park Photo Points of Spurge Control	PLANT	leafy spurge	Park		
KNRI	Park Monitoring of Number of Visitors	VISITOR	visitor use	Park		
KNRI	Pesticide Use	WATER	all aquatic resources	Park		
KNRI	EPA Storet Database Sampling Sites	WATER	water quality	EPA		
KNRI	SDSU Water Quality Project	WATER	all aquatic resources	SDSU	2004	
KNRI	USGS Water Gauge	WATER	river	USGS		

MNRR	Terns and Plovers by Corp of Engineers	ANIMAL	terns and plovers	Corp of Engineers		annually
MNRR	Asian Carp Monitoring by Hesse	ANIMAL	Asian carp			
MNRR	Benthic Fish Study by USGS	ANIMAL	benthic fish community			
MNRR	Fish Monitoring by State Agencies	ANIMAL	fish community			
MNRR	Pallid Sturgeon Monitoring by FWS	ANIMAL	pallid sturgeon			
MNRR	Sauger by Stephen Wilson	ANIMAL	sauger			
MNRR	Zebra Mussel Monitoring by Hesse	ANIMAL	zebra mussels			
MNRR	Zebra Mussel Traps by Wilson	ANIMAL	zebra mussels	Park		
MNRR	Corp of Engineers River Imagery	GEOLOGY	river	Corp of Engineers		
MNRR	Bio-control Project	PLANT	vascular plants	Park		
MNRR	Local Schools Water Monitoring on Tributaries	WATER	river			
MNRR	EPA Storet Database Sampling Sites	WATER	water quality	EPA		
MNRR	SDSU Water Quality Project	WATER	all aquatic resources	SDSU	2004	
MNRR	Corp Dam Releases and Operations	WATER	river			
MORU	RAWS Weather Monitoring	AIR		Western Regional Climate Center under NOAA		
MORU	Geology Monitoring of Mountain by ReSpec	GEOLOGY	Mt. Rushmore	Park		
MORU	Fire Effects Monitoring	PLANT	vascular plants	Fire Effects		variable
MORU	EPMT Exotic Plant Control	PLANT	vascular plants	EPMT		annually
MORU	Park Monitoring of Number of Visitors	VISITOR	visitor use	Park		
MORU	Pesticide Use	WATER	all aquatic resources	Park		
MORU	Well Water Monitoring	WATER	drinking water			
MORU	EPA Storet Database Sampling Sites	WATER	water quality	EPA		
MORU	SDSU Water Quality Project	WATER	all aquatic resources	SDSU	2004	
NIOB	Weather	AIR		Park		
NIOB	State Monitoring for Whirling Disease	ANIMAL	trout	Nebraska Game and Parks Commission		
NIOB	State CWD Monitoring	ANIMAL	deer	State of Nebraska		
NIOB	Park Monitoring of Terns and Plovers	ANIMAL	terns and plovers	Park		annually
NIOB	UNL Small Mammal and Grassland Bird responses t	ANIMAL	bird community, mammal	U. of Nebraska-Lincoln	2004	
NIOB	State Fish Monitoring	ANIMAL	fish community	Nebraska Game and Parks Commission		
NIOB	I&M Program Herp Inventory	ANIMAL	herp community	NGPN I&M Program	2003	
NIOB	The Nature Conservancy Woodrat Study	ANIMAL	Bailey's eastern woodrat	The Nature Conservancy		annually
NIOB	TNC 10-Year Biota Inventory - Animal	ANIMAL			1981	every 10 years
NIOB	Park Photographs of Developments	LAND USE		Park		annually
NIOB	The Nature Conservancy Fire Effects Monitoring	PLANT	vascular plants	The Nature Conservancy		
NIOB	The Nature Conservancy Vegetation Monitoring	PLANT	vascular plants	The Nature Conservancy		
NIOB	Bragg Vegetation Plots on TNC Preserve	PLANT	vascular plants		1984	annually
NIOB	Knezevic Pesticide Effectiveness Project	PLANT	purple loosestrife, red cedar	University of Nebraska-Lincoln		
NIOB	TNC 10-Year Biota Inventory - Plants	PLANT	vascular plants		1981	every 10 years
NIOB	NRCS Soil Erosion on Lower Niobrara River	SOIL		NRCS		
NIOB	DEQ 5-Year Surveys	WATER	river	Nebraska Dept. of Environmental Quality		every five years
NIOB	SDSU Water Quality Project	WATER	all aquatic resources	SDSU	2004	
NIOB	Park River Monitoring	WATER	all aquatic resources	Park	2001	2x/week

NIOB	USGS Flow Station	WATER	river	USGS		on going
NIOB	Waterfall Study on Niobrara	WATER	river/geologic resources	U. of Nebraska-Lincoln	2003	
SCBL	City of Scottsbluff Air Quality	AIR		City of Scotts Bluff		
SCBL	RAWS Weather Monitoring	AIR		Western Regional Climate Center under NOAA		
SCBL	Audubon Breeding Bird Count	ANIMAL	bird community			
SCBL	Audubon Club Christmas Bird Count	ANIMAL	bird community			
SCBL	Gypsy Moth Monitoring	ANIMAL	gypsy moth	State of Nebraska		
SCBL	CWD Monitoring by State	ANIMAL	deer	State of Nebraska		
SCBL	LTEM Prairie Dog Monitoring	ANIMAL	prairie dog	Prairie Cluster LTEM		annually
SCBL	CDC Hantavirus Study	ANIMAL	rodent community	Centers for Disease Control	1997	
SCBL	Geology Monitoring by Cannia	GEOLOGY	Bluffs	State of Nebraska		
SCBL	Fire Effects Monitoring	PLANT	vascular plants	Fire Effects		variable
SCBL	LTEM Vegetation Monitoring	PLANT	vascular plants	Prairie Cluster LTEM		
SCBL	EPMT Exotic Plant Control	PLANT	vascular plants	EPMT		annually
SCBL	Sedge Restoration Monitoring	PLANT	sedge			
SCBL	Park Monitoring of Number of Visitors	VISITOR	visitor use	Park		
SCBL	Pesticide Use	WATER	all aquatic resources	Park		
SCBL	State Water Quality Monitoring	WATER	river	State of Nebraska		periodic
SCBL	SDSU Water Quality Project	WATER	all aquatic resources	SDSU	2004	
SCBL	NOAA Groundwater	WATER	groundwater			
SCBL	EPA Storet Database Sampling Sites	WATER	water quality	EPA		
THRO	Interagency Monitoring of Protected Visual Environments	AIR	air quality/aerosols	NPS	12/1/1999	
THRO	National Atmospheric Deposition Program NADP/NTN)	AIR	air quality	NPS	1/1/2001	
THRO	Gaseous Pollutant Monitoring Network GPMN)	AIR	air quality	NPS		
THRO	Clean Air Status and Trends Network CASTNet)	AIR	air quality	EPA/NPS	10/6/1998	
THRO	State Air Quality Station in North Unit	AIR	air quality	North Dakota Dept. Health		
THRO	State Air Quality Station in South Unit	AIR	air quality	North Dakota Dept. Health		
THRO	NOAA- Climate Reference Network Station USCRN)	AIR	weather	NOAA	2004	
THRO	Weather Monitoring by NOAA	AIR	weather	NOAA		
THRO	Weather Monitoring in North Unit	AIR	weather			
THRO	Christmas Bird Count	ANIMAL	bird community	Park		annually
THRO	Golden Eagle Nest Monitoring	ANIMAL	golden eagle	Park		
THRO	ARMI Studies	ANIMAL	herp community	USGS-BRD		
THRO	Gypsy Moth Monitoring	ANIMAL	gypsy moth	State of North Dakota		
THRO	Bison Reduction Roundup	ANIMAL	bison	Park		Annual/ periodic
THRO	Chronic Wasting Disease in Cervids	ANIMAL	elk, deer	State of North Dakota		annually
THRO	Elk Surveys	ANIMAL	elk	Park		Annuall/periodic
THRO	Horse Surveys	ANIMAL	feral horse	Park		annually
THRO	Horse Reduction Roundup	ANIMAL	feral horse	Park		periodically
THRO	Bighorn Sheep Monitoring	ANIMAL	bighorn sheep	Park		annually
THRO	Prairie Dog Monitoring	ANIMAL	prairie dog	Park		every couple years
THRO	State Mule Deer Monitoring	ANIMAL	mule deer	State of North Dakota		annually

THRO	Fire Effects Monitoring	PLANT	vascular plants	Fire Effects		variable
THRO	Park Photo Points	PLANT	vascular plants	Park	late 90s	
THRO	EPMT Exotic Plant Control	PLANT	vascular plants	EPMT		annually
THRO	Exotic Plant Infestations	PLANT	vascular plants	Park		annually
THRO	Park Monitoring of Backcountry Use	VISITOR	visitor use	Park		
THRO	Park Monitoring of Number of Visitors	VISITOR	visitor use	Park		
THRO	Pesticide Use	WATER	all aquatic resources	Park		
THRO	EPA Storet Database Sampling Sites	WATER	water quality	EPA		
THRO	SDSU Water Quality Project	WATER	all aquatic resources	SDSU	2004	
THRO	USGS Flow Station Medora	WATER	river	USGS		
THRO	USGS Flow Station Watford City	WATER	river	USGS		
WICA	CASTNET	AIR	air quality	NPS	1/1/2004	weekly
WICA	IMPROVE Air Quality Monitoring	AIR	air quality	NPS	12/1/1999	weekly
WICA	NADP	AIR	air quality		11/1/2002	weekly
WICA	RAWS Weather Monitoring	AIR		Western Regional Climate Center under NOAA		
WICA	Radon Monitoring cave)	AIR	cave	park	1975	bi-annually
WICA	Inactive Passive O3 Site	AIR	air quality	NPS	5/1/1995	weekly
WICA	Breeding Bird Survey Route	ANIMAL	bird community	USGS-BRD	1997	
WICA	Breeding Bird Transects	ANIMAL	bird community	Park		annually
WICA	Christmas Bird Count	ANIMAL	bird community	USGS-BRD		annually
WICA	Owl Surveys	ANIMAL	saw-whet and flammulated owls	Park		periodic
WICA	Sharp-tailed Grouse Leks	ANIMAL	sharp-tailed grouse	Park		Annual/periodic
WICA	Survey for Raptor Nests	ANIMAL	raptors	Park		periodic
WICA	Tiger Salamander Monitoring	ANIMAL	tiger salamanders	Park		Annual/periodic
WICA	Gypsy Moth Monitoring	ANIMAL	gypsy moth	Forest Service		annually
WICA	Bat Surveys	ANIMAL	bats	Park	recent	periodic
WICA	Bison Roundup	ANIMAL	bison	Park		Annual/periodic
WICA	Chronic Wasting Disease in Cervids	ANIMAL	elk, deer	Park	2003	continuous
WICA	Diseases in Coyotes	ANIMAL	coyote	Park		
WICA	Elk Aerial Surveys in Cooperation with State	ANIMAL	elk	Park		periodic
WICA	Ground Surveys for Pronghorn	ANIMAL	pronghorn	Park		annually
WICA	Prairie Dog Monitoring	ANIMAL	prairie dog	Park		annually
WICA	Moore, Cave biota study	ANIMAL	cave, biota			
WICA	Cave feature inventory	GEOLOGY	cave	park		
WICA	Fire Effects Monitoring	PLANT	vascular plants	Fire Effects		variable
WICA	Forest Service Forest Inventory and Analysis Program	PLANT	vascular plants	Forest Service		
WICA	Photo Points	PLANT	vascular plants	Park		
WICA	Photo Points from Integral Vista Study	PLANT	vascular plants	Park		
WICA	Scorecard Monitoring of Vegetation	PLANT	vascular plants	Park		periodic
WICA	EPMT Exotic Plant Control	PLANT	vascular plants	EPMT		annually
WICA	WICA Exotic Plant Control	PLANT	vacsular plants	Park		annually
WICA	Mapping and Photo Points of Aspen	PLANT	aspen	Park		

WICA	Range Assessment Using NRCS Protocol	PLANT	vascular plants	Park	2003	annually
WICA	Large mammalian, plant interactions	PLANT	vascular plants	Park	1995	periodic
WICA	Improve Native Seed Mix	PLANT	vascular plants	USGS-BRD	2004	annually
WICA	Inventory Project of Eumycetozoans slime molds)	SLIME MOLD	slime molds	National Science Foundation	2004	periodic
WICA	Park Monitoring of Backcountry Use	VISITOR	visitor use	Park		monthly
WICA	Park Monitoring of Number of Visitors	VISITOR	visitor use	Park		monthly
WICA	Monitoring of off-trail cave use	VISITOR		park	1986	
WICA	Park Monthly Monitoring of Water Quality	WATER	stream	Park	1998	monthly
WICA	Pesticide Use	WATER	all aquatic resources	Park		
WICA	Water Wells	WATER	drinking water	Park		
WICA	EPA Storet Database Sampling Sites	WATER	water quality	EPA		
WICA	SDSU Water Quality Project	WATER	all aquatic resources	SDSU	2004	
WICA	USGS Station on Beaver Creek	WATER	river	USGS	1991	Continuous
WICA	Water Level Monitoring in Cave	WATER	groundwater	Park		monthly
WICA	Spring water quality	WATER	surface water, springs	park	2002	
WICA	Cave water quality	WATER	cave, groundwater	park	1989	
WICA	Cave micro-climate	WEATHER	cave	park	1986	
WICA	Dust Deposition Monitoring cave)		cave	park	2002	

Inactive Monitoring and Applicable Research Projects

PARK	PROJECT TITLE	CATEGORY	RESOURCE, I.E., VITAL SIGN	LEAD AGENCY	START	END
AGFO	Cook et al. 1986 Survey for Rare Raptors	ANIMAL	raptor community			
AGFO	Powell 2000 Bird Inventory	ANIMAL	bird community	USGS-BRD		
AGFO	Stasiak Fish Inventory	ANIMAL	fish community			
AGFO	I&M Program Butterfly Inventory	ANIMAL	butterfly community	NGPN I&M Program	2004	2004
AGFO	I&M Program Mammal Inventory	ANIMAL	mammal community	NGPN I&M Program	2003	2003
AGFO	Graetz et al. Faunal Survey	ANIMAL	wildlife community			
AGFO	NPS and USGS Vegetation Mapping Project	PLANT	vascular plant community	NPS		inactive
AGFO	Weedon et al. Vegetation Surveys	PLANT	vascular plant community			
AGFO	Stubbendieck et al. Exotic Plant Assessment	PLANT	vascular plant community			
AGFO	Wetmore Lichen Study	PLANT	lichens			
AGFO	Park Bio-control Project Soil Monitoring	SOIL	soil	Park		current
AGFO	Harris et al. 1991 Assessment of Aquatic Resources	WATER	unknown			
AGFO	Sundermann Wetland Delineation Study	WATER	surface water			
AGFO	USGS Water Gauge	WATER	river flow	USGS		2004
BADL	Transmissometer passive 03)	AIR		Park	5/1/2000	7/1/2002
BADL	Weather Station at Park Headquarters	AIR		Park	1987	1992
BADL	Hull-Sieg Juniper Woodland Study	ANIMAL	bird community			
BADL	Powell 2000 Bird Inventory	ANIMAL	bird community			
BADL	Berry 1999 Fish Inventory in White River	ANIMAL	fish community			
BADL	Cunningham et al. Fish Surveys	ANIMAL				
BADL	Fryda Fish Survey of White River	ANIMAL				
BADL	Smith Herpetofuana Inventory	ANIMAL				
BADL	Quinn Grasshopper Study	ANIMAL				
BADL	Bogan et al. Bat Inventories in Early 90s	ANIMAL	bats			
BADL	Livieri Predator Surveys	ANIMAL				
BADL	Butler and Batt Vegetation Studies in Early 90s	PLANT				
BADL	Lindstrom Flowering Plant Survey	PLANT				
BADL	NPS and USGS Vegetation Mapping Project	PLANT	vascular plants	NPS		inactive
BADL	Olson Steppe Vegetation Report	PLANT				
BADL	Whisenant and Uresk Spring Burning Study	PLANT				
BADL	Detling Grazing Study	PLANT	vascular plants			inactive
BADL	Dingman Rare Plant Study	PLANT	vascular plants	USD	2003	2004
BADL	Park Double Sampling Range Evaluation	PLANT	vascular plants	Park		
BADL	1990s Sound Study	SOUND				early 90s
BADL	Sound for Air Tour Plan	SOUND				inactive
DETO	I&M Program Bird Inventory Transects	ANIMAL	bird community	NGPN I&M Program	2002	2004
DETO	I&M Program Fish Inventory	ANIMAL	fish community	NGPN I&M Program	2001	2001
DETO	I&M Program Herp Inventory	ANIMAL	herp community	NGPN I&M Program	2002	2003
DETO	Ferris 1985 Insect Survey	ANIMAL			1983	1985
DETO	I&M Program Butterfly Inventory	ANIMAL	butterfly community	NGPN I&M Program	2004	2004

DETO	I&M Program Mammal Inventory	ANIMAL	mammal community	NGPN I&M Program	2003	2003
DETO	Armstrong Baseline Faunal Inventory	ANIMAL	wildlife community			
DETO	Permanent Grasshopper Site Survey	ANIMAL	grasshopper	USDA APHIS PPQ	1989	1992+?
DETO	Population and Habitat Ecology of Deer on DETO	ANIMAL	deer	University of Wyoming	1990	1991
DETO	Golden and Bald Eagle Monitoring	ANIMAL	golden and bald eagles	park	1992	1998
DETO	Description of Vascular Flora and Mammals and Effects of Human Disturbance on the Summit of Devils Tower	PLANT	Tower summit flora, fauna, human disturbance		1992	1992
DETO	NPS and USGS Vegetation Mapping Project	PLANT	vascular plants	NPS		inactive
DETO	Study of Deciduous Woodlands and Thickets at DETO	PLANT	vascular plants	WYNDD	1996	
DETO	Merrill Study of Deer Browsing	PLANT	vascular plants	UW Wisconsin	1989	1996
DETO	Fertig Rare Plant Study	PLANT				
DETO	Fisher at al. Fire and Prairie Mosaic Study	PLANT				
DETO	Monitoring Rare and Noxious Plant Species at DETO	PLANT			1987	1988
DETO	Early 1990s Soil Study on Tower	SOIL				early 90s
DETO	1 Year Sound Study	SOUND	natural sound		1997	1998
FOLA	I&M Program Bird Inventory	ANIMAL	bird community	NGPN I&M Program	2002	2004
FOLA	I&M Program Fish Inventory	ANIMAL	fish community	NGPN I&M Program	2001	2001
FOLA	I&M Program Herp Inventory	ANIMAL	herp community	NGPN I&M Program	2002	2003
FOLA	I&M Program Butterfly Inventory	ANIMAL	butterfly community	NGPN I&M Program	2004	2004
FOLA	I&M Program Mammal Inventory	ANIMAL	mammal community	NGPN I&M Program	2003	2003
FOLA	I&M Program Plant Inventory	PLANT	vascular plants	NGPN I&M Program	2003	2004
FOLA	NPS and USGS Vegetation Mapping Project	PLANT	vascular plants	NPS		inactive
FOLA	Fertig Rare Plant Study	PLANT	vascular plants			
FOUS	I&M Program Bird Inventory Transects	ANIMAL	bird community	NGPN I&M Program	2002	2004
FOUS	I&M Program Herp Inventory	ANIMAL	herp community	NGPN I&M Program	2002	2003
FOUS	I&M Program Butterfly Inventory	ANIMAL	butterfly community	NGPN I&M Program	2004	2004
FOUS	I&M Program Mammal Inventory	ANIMAL	mammal community	NGPN I&M Program	2003	2003
FOUS	Bradybaugh Vegetation Study	PLANT	vascular plants	Park		inactive
FOUS	I&M Program Plant Inventory	PLANT	vascular plants	NGPN I&M Program	2003	2004
FOUS	NPS and USGS Vegetation Mapping Project	PLANT	vascular plants	NPS		inactive
FOUS	Willard Vegetation Report	PLANT	vascular plants	Park		
FOUS	USGS Water Gauge	WATER	river flow	USGS		
JECA	1996 Bird Monitoring Survey	ANIMAL	bird community			
JECA	Cole 1984 Bird Inventory	ANIMAL	bird community			
JECA	I&M Program Bird Inventory Transects	ANIMAL	bird community	NGPN I&M Program	2002	2004
JECA	I&M Program Herp Inventory	ANIMAL	herp community	NGPN I&M Program	2002	2003
JECA	I&M Program Butterfly Inventory	ANIMAL	butterfly community	NGPN I&M Program	2004	2004
JECA	Bogan and Ramotnik Baseline Mammal Survey	ANIMAL	mammal community			
JECA	I&M Program Mammal Inventory	ANIMAL	mammal community	NGPN I&M Program	2003	2003
JECA	Marriott 1986 Floristic Inventory	PLANT				
JECA	NPS and USGS Vegetation Mapping Project	PLANT	vascular plants	NPS		inactive
JECA	Early 90s Cave Water Quality Monitoring	WATER	groundwater	Park	early 90s	inactive
KNRI	High School Bird Monitoring	ANIMAL	bird community	Center and Hazen High Schools	early 90s	current

KNRI	I&M Program Bird Inventory Transects	ANIMAL	bird community	NGPN I&M Program	2002	2004
KNRI	Peterka Fish Survey	ANIMAL				
KNRI	I&M Program Herp Inventory	ANIMAL	herp community	NGPN I&M Program	2002	2003
KNRI	I&M Program Butterfly Inventory	ANIMAL	butterfly community	NGPN I&M Program	2004	2004
KNRI	I&M Program Mammal Inventory	ANIMAL	mammal community	NGPN I&M Program	2003	2003
KNRI	Clambey 1985 Baseline Vegetation Study	PLANT				
KNRI	Lenz Vegetation Report and Map	PLANT				
KNRI	NPS and USGS Vegetation Mapping Project	PLANT	vascular plants	NPS		
MNRR	I&M Program Herp Inventory	ANIMAL	herp community	NGPN I&M Program	2002	2003
MNRR	Perkins and Backlund Mussel Survey	ANIMAL				
MNRR	I&M Program Mammal Inventory	ANIMAL	mammal community	NGPN I&M Program	2004	2004
MNRR	I&M Program Vegetation Inventory	PLANT	vascular plants	NGPN I&M Program		
MORU	State Air Quality Monitoring	AIR		State of South Dakota		1994
MORU	I&M Program Bird Inventory Transects	ANIMAL	bird community	NGPN I&M Program	2002	2004
MORU	I&M Program Fish Inventory	ANIMAL	fish community	NGPN I&M Program	2001	2001
MORU	I&M Program Herp Inventory	ANIMAL	herp community	NGPN I&M Program	2002	2003
MORU	I&M Program Butterfly Inventory	ANIMAL	butterfly community	NGPN I&M Program	2004	2004
MORU	I&M Program Mammal Inventory	ANIMAL	mammal community	NGPN I&M Program	2003	2003
MORU	Hoffman and Hansen 1986 Vegetation Study	PLANT				
MORU	NPS and USGS Vegetation Mapping Project	PLANT	vascular plants	NPS		
MORU	Gabel and Ebbert Fungal Inventory	PLANT				
MORU	Aircraft Overflight Study	SOUND		Park		
MORU	U. of Santa Barbara Water Study	WATER	all aquatic resources			
NIOB	Sedgwick and Bogan Bird Studies at Ft. Niob/Valentine	ANIMAL	bird community			
NIOB	Jennings and Bogan Fish Inventory at Ft. Niob/Valentine	ANIMAL	fish community			
NIOB	Corn et al. Herp Inventory of Ft. Niobrara and Valentine	ANIMAL				
NIOB	Kantak Middle Nobrara Plant Community Study	PLANT	vascular plants			
SCBL	Powell 2000 Bird Inventory	ANIMAL	bird community			
SCBL	I&M Program Fish Inventory	ANIMAL	fish community	NGPN I&M Program	2001	2001
SCBL	I&M Program Herp Inventory	ANIMAL	herp community	NGPN I&M Program	2002	2003
SCBL	I&M Program Butterfly Inventory	ANIMAL	butterfly community	NGPN I&M Program	2004	2004
SCBL	I&M Program Mammal Inventory	ANIMAL	mammal community	NGPN I&M Program	2003	2003
SCBL	Cox and Franklin Faunal Survey	ANIMAL	wildlife community			
SCBL	NPS and USGS Vegetation Mapping Project	PLANT	vascular plants	NPS		
SCBL	Weeden et al. 1986 Vegetation Survey	PLANT	vascular plants			
SCBL	Wendtland Study of Effects of Fire on Vegetation	PLANT	vascular plants			
SCBL	Wetmore Lichen Study	PLANT	lichens			
THRO	PRIMENET Air Quality Monitoring	AIR		EPA	1998	5/20/2004
THRO	NDAMN Air Quality Monitoring	AIR		EPA		
THRO	Discontinued Air Monitoring Station in North Unit	AIR			ca.1980	12/1/1997
THRO	Discontinued Air Quality Images and Visual Range	AIR		NPS	6/1/1905	1991
THRO	Discontinued NADP Site in South Unit	AIR		NPS	5/1/1981	12/1/2000

THRO	Discontinued South Unit Air Monitoring	AIR			6/2/1905	1989
THRO	Powell 2000 Bird Inventory	ANIMAL	bird community			
THRO	EPA Fish Sampling	ANIMAL	fish community	Environmental Protection Agency		
THRO	FWS Fish Inventories	ANIMAL	fish community	Fish and Wildlife Service		
THRO	Peterka Fish Survey	ANIMAL	fish community			
THRO	Hopkins 1983 Herpetofauna Habitat Study	ANIMAL				
THRO	Hossack et al. 2002 Amphibian Survey	ANIMAL				
THRO	Fleas on Prairie Dogs	ANIMAL	fleas	State of North Dakota		
THRO	Kritsky Grasshopper Inventory	ANIMAL	grasshoppers	NGPN I&M Program	2004	2004
THRO	Kritsky Tiger Beetle Inventory	ANIMAL	tiger beetles		2002	2003
THRO	Elk Roundups	ANIMAL	elk	Park		
THRO	Hopkins 1983 Small Mammal Habitat Study	ANIMAL				
THRO	Naylor Study of Small Mammals	ANIMAL	small mammals, woody draws			
THRO	Blaney and Norris Bryophytes of South Unit Study	PLANT				
THRO	Hansen 1980 Study of Vegetation	PLANT				
THRO	NPS and USGS Vegetation Mapping Project	PLANT	vascular plants	NPS		
THRO	Vegetation Monitoring with Whitaker Plots	PLANT	vascular plants	Park	2002	2003
THRO	Butler Exotic Plant Study	PLANT	vascular plants		1992	2003
THRO	Larson Exotic Plant Study	PLANT	vascular plants	NPS	1996	1997
THRO	Larson Leafy Spurge Research Project	PLANT	leafy spurge		1999	2002
THRO	Trammel Exotic Plant Study	PLANT				
THRO	Butler Grazing and Green Ash Study	PLANT				
THRO	Irby Vegetation Monitoring	PLANT	vascular plants			late 90s
THRO	Heidel Inventory of Rare Plants	PLANT				
THRO	Butler and Goetz Vegetation and Soil Study	PLANT, SOIL				
THRO	Sound Monitoring at Elkhorn	SOUND		NPS	1996	1996
THRO	Monitoring for Tordon	WATER	all aquatic resources	Park	early 90s	early 90s
WICA	Inactive Haze Monitoring	AIR	air quality	NPS	1979	1991
WICA	Elk Roundups	ANIMAL	elk	Park		
WICA	Hetlet Raptor Survey	ANIMAL	raptors			
WICA	I&M Program Bird Inventory Transects	ANIMAL	bird community	NGPN I&M Program	2002	2004
WICA	Peterson Off Road Bird Surveys	ANIMAL	bird community			
WICA	I&M Program Fish Inventory	ANIMAL	fish community	NGPN I&M Program	2001	2001
WICA	Smith Herpetofuana Inventory	ANIMAL	Herpetofauna			
WICA	Lawson Systematic Odonata Survey	ANIMAL	Invertebrates			
WICA	Marrone Butterfly Survey	ANIMAL	Invertebrates			
WICA	Dalstead et al. Remote Sensing and Prairie Dog Study	ANIMAL	prairie dog			
WICA	Derting and Kruper Small Mammal and Predator Study	ANIMAL	small mammals			
WICA	Duckwitz Small Mammal Survey	ANIMAL	small mammals			
WICA	Krueger Bison, Pronghorn, and Prairie Dog Diet Study	ANIMAL	bison, pronghorn, prairie dog			
WICA	Forde Bird, Small Mammal, and Fire Study	ANIMAL	wildlife community			
WICA	Forde Plant and Fire Study	PLANT	vascular plants			

WICA	Gartner Vegetation Responses to Burning Study	PLANT	vascular plants			
WICA	Marriott Rare Plant Survey	PLANT	rare plants		1999	
WICA	NPS and USGS Vegetation Mapping Project	PLANT	vascular plants	NPS		
WICA	Black Hills Community Inventory	PLANT	vascular plants		1995	1999
WICA	Range Forage Inventory	PLANT	vascular plants	NPS	1943	
WICA	Study of Grassland Areas	PLANT	vascular plants	Kansas State College	1953	
WICA	Range Trend Study	PLANT	vascular plants	NPS	1951	
WICA	Study of Grass Density	PLANT	vascular plants	NRCS	1962	1967
WICA	Range Monitoring	PLANT	vascular plants	park	1981	
WICA	Range Condition	PLANT	vascular plants	park	1992	
WICA	Stohlgren Vegetation Study	PLANT			1996	
WICA	Singer Browse-Fire Study with Exclosures	PLANT			1995	1997
WICA	Coppock Prairie Dog and Vegetation Study	PLANT, ANIMAL	vascular plants			
WICA	Detling Grazing Study	PLANT, ANIMAL	vascular plants			
WICA	Cave Water Isotopic Study	WATER	cave, groundwater	park	1983	2002
WICA	Beaver Creek flow loss	WATER	stream, groundwater	park	1997	2003
WICA	Parking Lot Project Water Impact Monitoring	WATER	groundwater	USGS	1994	2003